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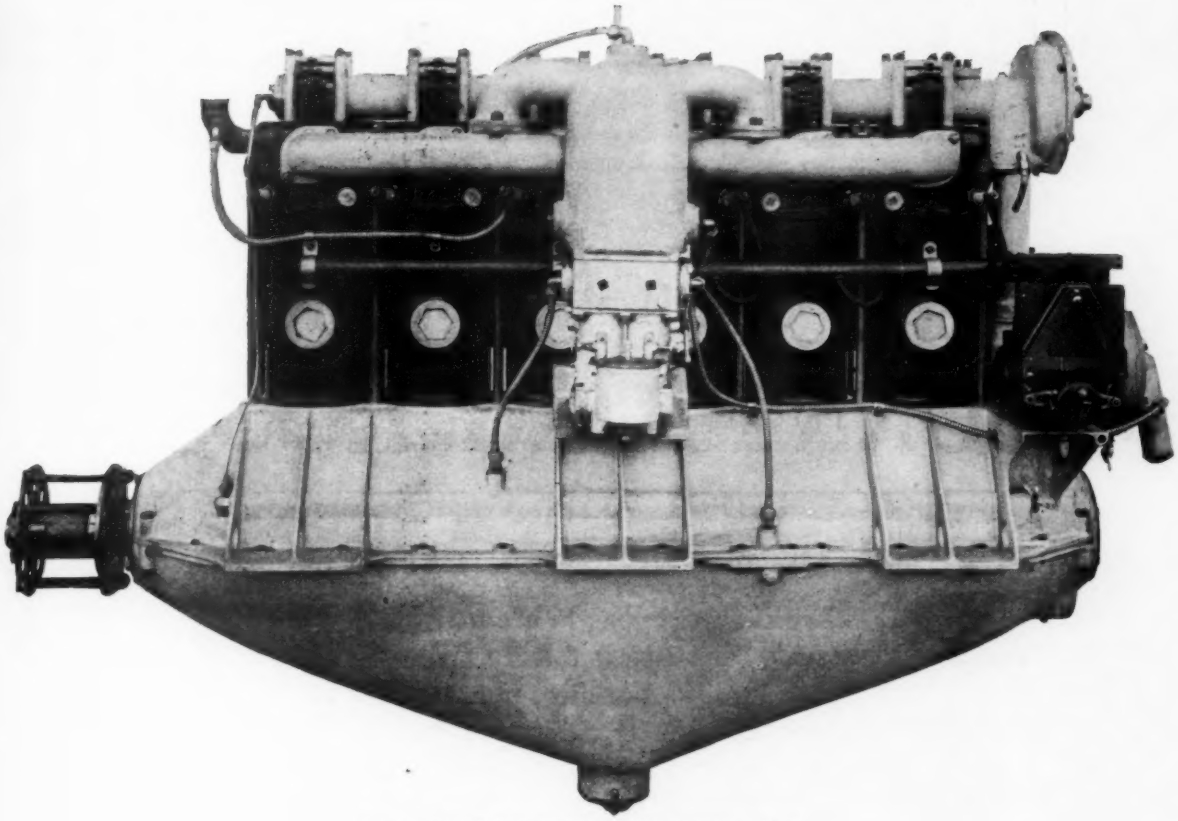

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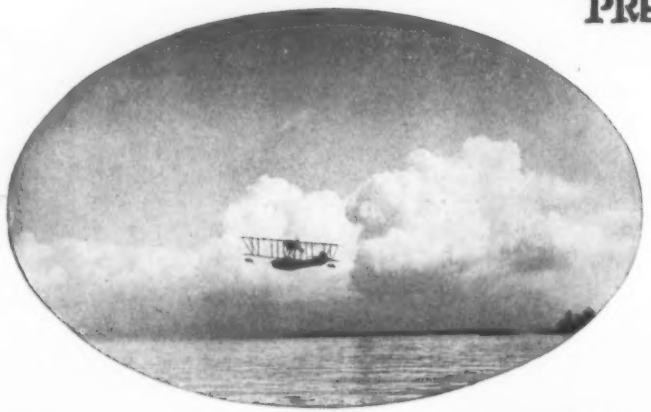

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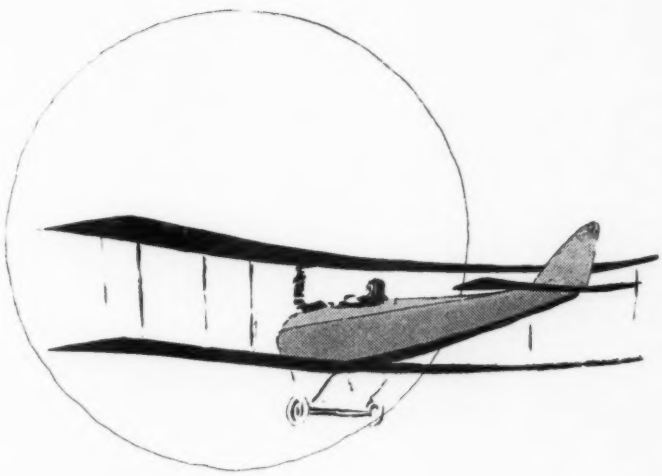

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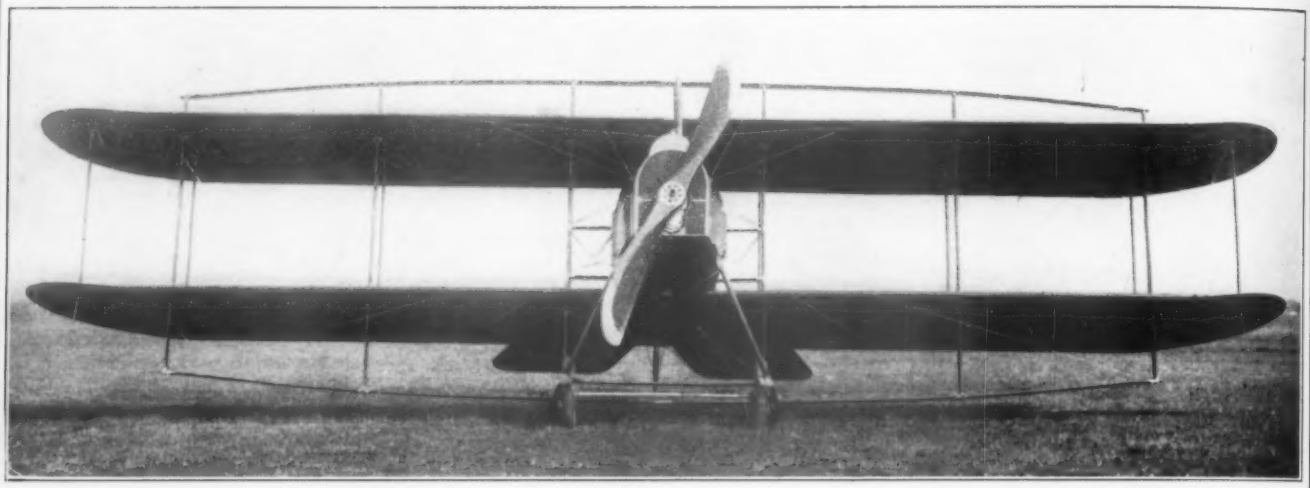

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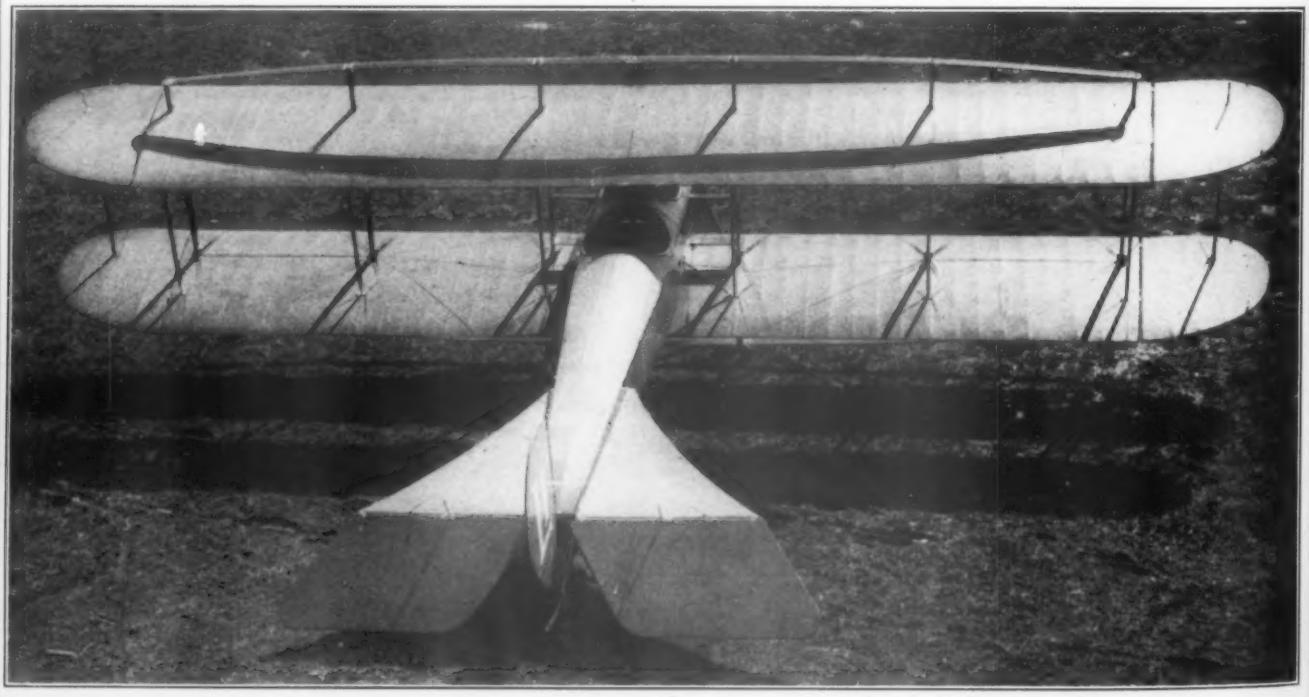

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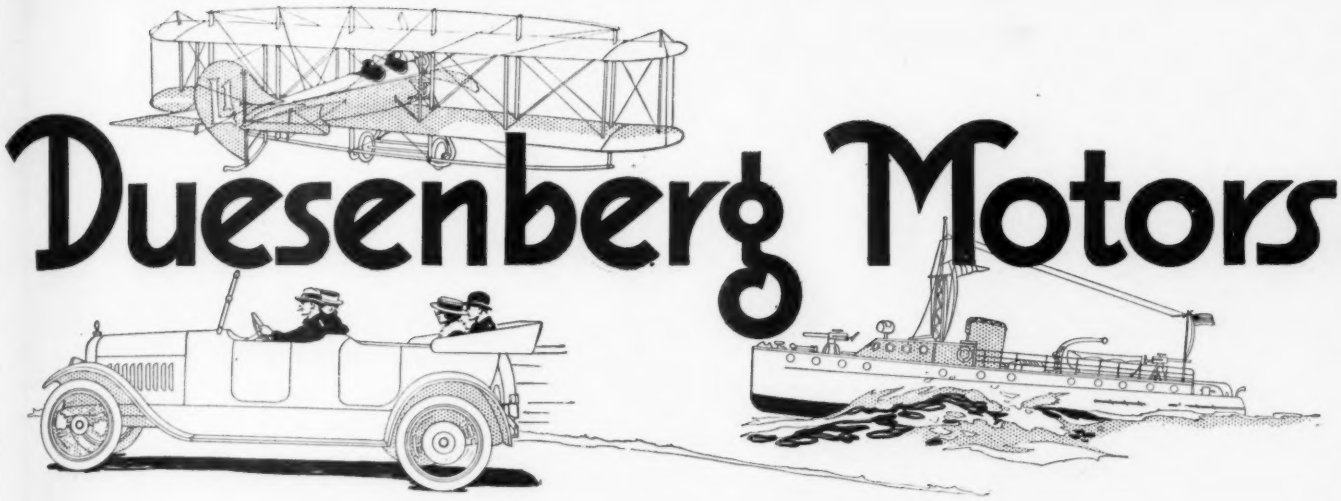

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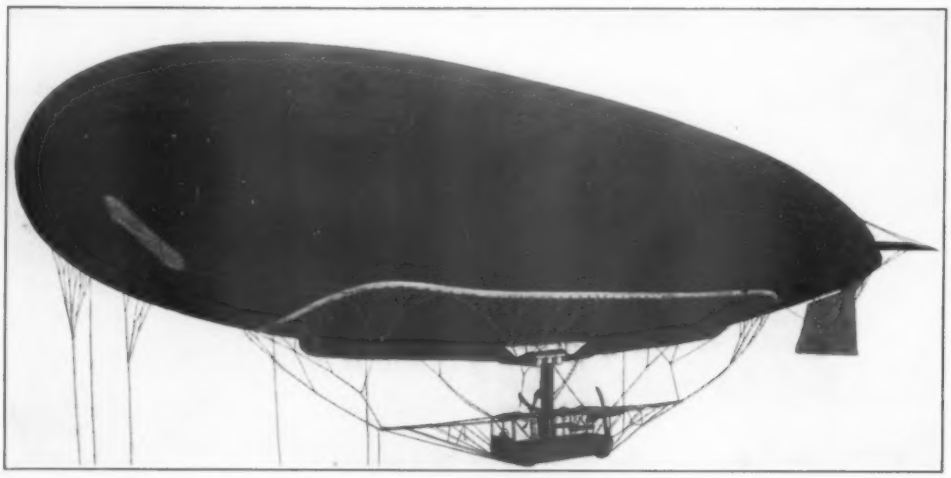

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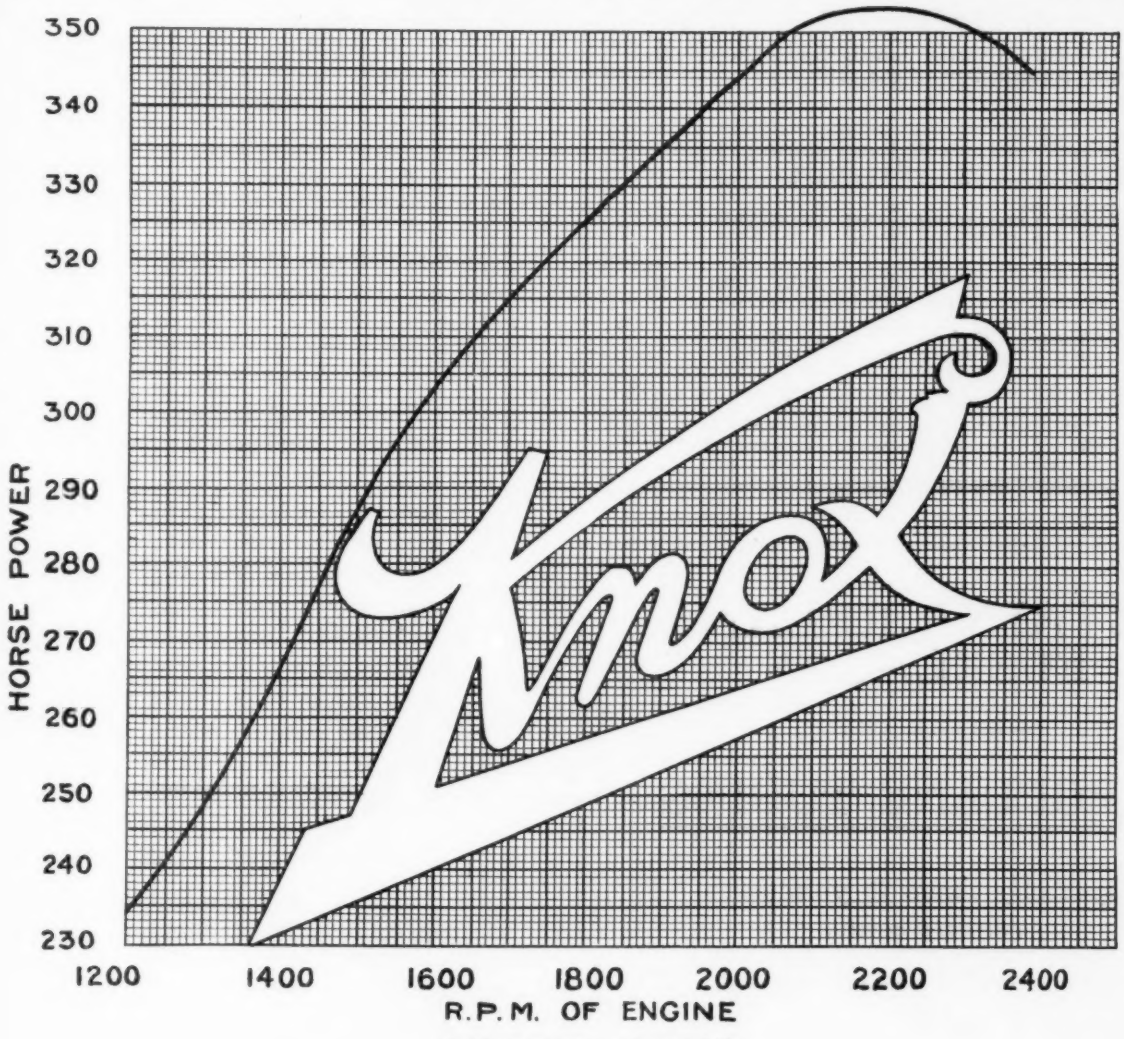

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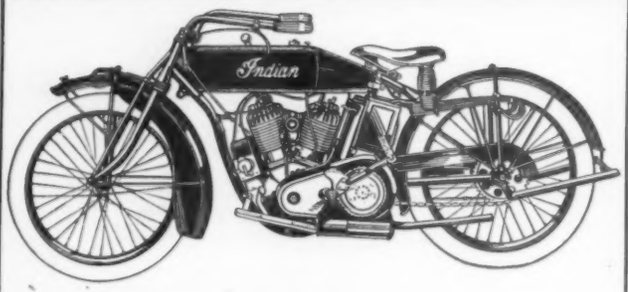

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VOL. II. NO. 7

Member of the Associated Business Papers

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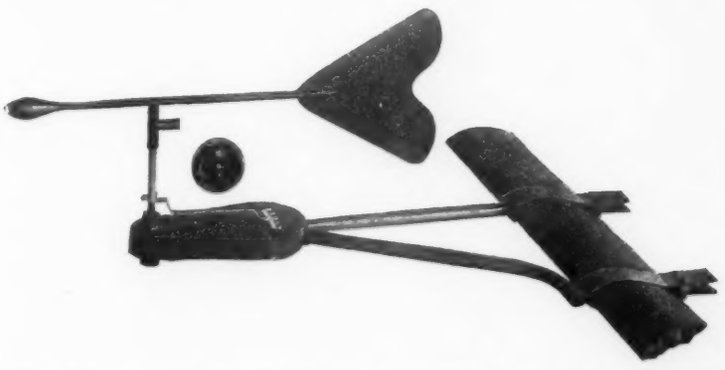

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AVIATION AND AERONAUTICAL ENGINEERING

TECHNICAL EDITOR
A. KLEMIN, A.C.G.I., B.Sc., S.M.
Instructor in Aeronautics
Massachusetts Institute of Technology

BUSINESS MANAGER
GEORGE NEWBOLD

Vol. II | May 1, 1917 | No. 7

THE time has arrived when information regarding the development of aviation in the United States will have to be divulged in guarded terms. It is fortunate, therefore, that the plans of the Signal Corps for the coming year have already been given out, for the knowledge that these plans are well under way will allay any fears regarding that branch of the service and will inspire continued confidence in those on whom the responsibility for this work devolves.

For Army aeronautics appropriations amounting to $62,000,000 have been asked for—a sum so large that a year ago it would have been considered impossible to secure. But the examples, as well as the mistakes of France and England, are now directly available, and no one doubts that they are receiving careful consideration by both the Army and the Navy.

Six million dollars are wanted for personnel. This amount will probably be ample to take care of all the pilots who can be trained with the machines which will be available.

Aviation is rapidly being recognized as the most attractive branch of military service. It is the one duty in which individual initiative in combat work is still possible. When a military aviator is sent on a mission the moment he leaves the ground he becomes an independent unit, as nearly as can be possible in military service. While acting under general orders, he is subjected to attack from enemy machines and anti-aircraft guns, which may make it necessary to instantly change all his plans. This independence of action, as well as the fact that aviation is looked upon as an American achievement, is attracting thousands of young men to the service. Unfortunately, with the limited equipment of airplanes comparatively few of these patriotic volunteers can hope to be trained in the near future.

Ten million dollars are wanted for the purchase of land and equipment for Army schools. Last year appropriations made no provision for the acquirement of permanent aviation sites, and as a result the Army is now training on leased land, on which, under the law, permanent improvements cannot be made. Investigation by experts in aeronautics of the site problem has brought out the fact that its solution will be difficult and expensive. Such a peculiar combination of physical conditions are required that the number of suitable locations is extremely limited.

The remaining $46,000,000 will be needed for the equipment of airplane squadrons and for training machines. In a situation like the present one, especially in view of the fact that the aviation service has been neglected so long by the Government, no time should be lost in making these funds available. And when they are available the work of building up the aeronautical industry must begin in earnest.

Orville Wright Reenters the Commercial Field

The return of Orville Wright to the commercial field of aeronautics will be noted with pleasure and satisfaction by all who believe that his contribution to the progress of the world did not stop with the model B.

With associates who are recognized in the engineering world as men of foresight and as practical manufacturers the new work to be undertaken under Mr. Wright's direction will be watched with the greatest interest by all connected with aeronautics.

Speeding Up Production

The question of speeding up production is the most important problem at this time. The Government is in urgent need of the machines that are already on order so that it can train aviators; it is anxious to place further contracts with manufacturers who can give satisfactory assurances that they are in position to receive orders for prompt delivery of airplanes, dirigibles, and balloons, so that training can be given to the many more fliers than the comparatively few machines now delivered or ordered can provide.

It is to the advantage of all manufacturers of aircraft, as well as of aeronautical accessories, to so arrange their facilities as to be in position to assist the Government in every possible manner. While these manufacturers have been working with whole-hearted interest and energy in building up the new industry, any special efforts which they, with their constantly widening experience, may now be able to put forth cannot help but receive recognition by the War and Navy Departments. Such efforts will further serve as the best assurance of receiving a share of the larger orders that are sure to be placed in the near future.

Plans of wide scope are being effected for the closest cooperation between Federal, State and local governments and the farmers, shipbuilders, and munition manufacturers, and this cooperation is taking the form of loans and other indirect financial assistance.

There is certainly as great a need for the Government to extend this broad emergency policy to include airplane manufacturers, if those of the smaller companies who have demonstrated that they can produce efficient airplanes are to assist in securing the necessary production required for the training of aviators. It would be a wise step, in view of the emergency conditions.

The Construction of Airplane Propellers

By Frank W. Caldwell

There are a large number of woods used in the construction of airplane propellers and the selection of one suitable to meet the conditions in hand is not always an easy problem.

The woods most commonly used in American practice are: birch, Honduras mahogany and white oak. Other woods that are sometimes employed are: maple, spruce, poplar, ash, and gum.

In England Honduras mahogany and black walnut are most widely used and the preference seems to be for the black walnut. Spruce is used to some extent for the smaller engines.

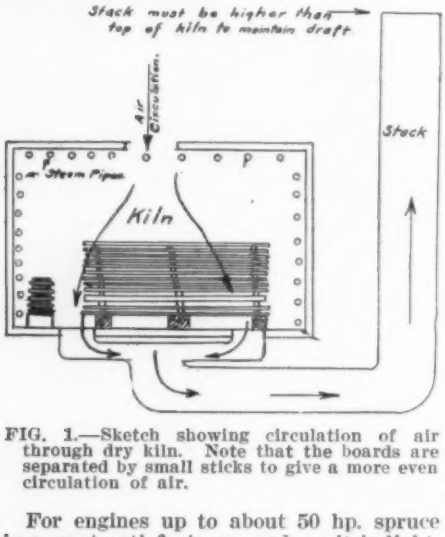

FIG. 1.—Sketch showing circulation of air through dry kiln. Note that the boards are separated by small sticks to give a more even circulation of air.

For engines up to about 50 hp. spruce is a most satisfactory wood, as it is light, strong, easy to glue, and is not excessively affected by changes in climatic conditions.

For engines of from 60 to 100 hp. alternate laminations of maple and spruce have been used in a great many cases. The arrangement is always made so that the maple boards come on the outside in order that the harder wood may come in contact with the metal hub plate and prevent the plates from sinking into the wood. This arrangement is not recommended, however, as the woods have a different coefficient of expansion (not to be confused with the thermal coefficient of expansion) with changes in humidity. This causes warping and season checks which usually show up in the spruce as it is the weaker wood.

Honduras mahogany has been used for

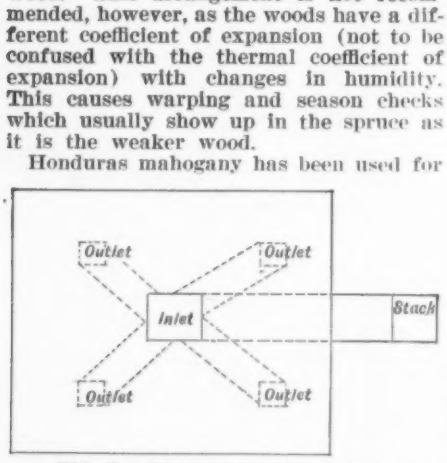

FIG. 2.—Plan arrangement of kiln.

these engines and has given very good results as it is very easy to glue, is comparatively light, and is very little affected by climatic changes. It is easily marred, however, and is only moderately strong.

Quarter-sawed white oak has given about the best results for from 60 to 100 hp. engines. It has a very high tensile strength, and a high compressive strength across the grain and is not very much affected by climatic changes. Only absolutely dry stock should be used, otherwise trouble with the glue joints will be encountered. The material must be quarter-sawed or layed out to give an edge grain as the plain oak has a very decided tendency to develop season checks. The use of edge grain will be explained later.

Wood for Large Horsepowered Engines

For the very large engines of about 200 h.p. it is rather hard to say which wood has given the best results. In order to keep down the weight the hub flanges are usually made as small as possible and this makes it necessary to have a very high bearing pressure on the hub plates so that the friction between them and the wood may be great enough to drive the propeller. This makes it necessary to use wood with a high compressive strength across the grain in order to prevent the hub plates from sinking into the wood. Birch shows more resistance to this than any other wood with the possible exception of maple. Birch is also very tough, has a high tensile strength, and is not prohibitively heavy. It is very hard to glue, however, and must be dried very carefully to get good results. It is very much affected by climatic changes and will warp and check badly under certain conditions. This is particularly true where thin sections are used.

Quartered white oak is a very good material for use with big engines. It is to be preferred to birch in most cases.

For extreme climatic conditions such as those encountered on the Mexican border Honduras mahogany is preferable on account of the fact that it is least affected by the climate.

Poplar Used in Mexico

On the Mexican border it was found possible to get poplar that was well seasoned in that climate and this wood had to be given preference for this reason. The poplar seemed to retain its strength better under the extremly dry conditions than the other woods. Most wood becomes brittle or "brackish" in the climate of the Mexican border.

The use of gum is not recommended as it will warp and check very badly even if thoroughly seasoned.

Ash is not recommended as it is hard to laminate properly aud has a tendency to splinter.

Black walnut has not been used to any extent in the United States, but is used a great deal in England. It is probably less affected by climatic conditions than any other propeller wood.

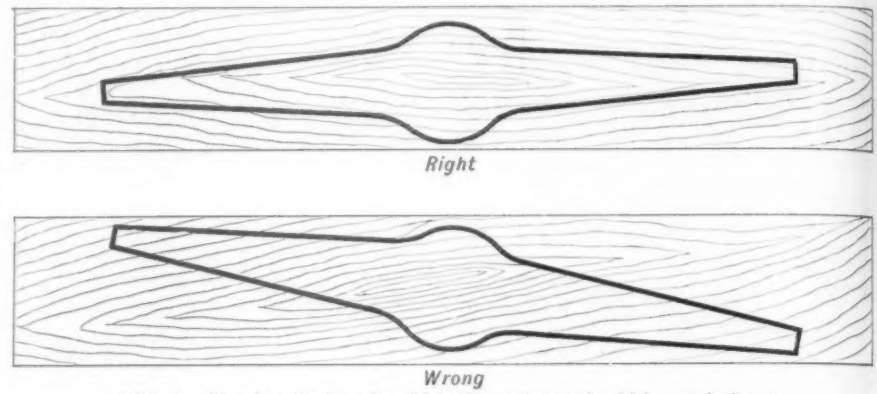

FIG. 3.—Showing the way in which the patterns should be marked out.

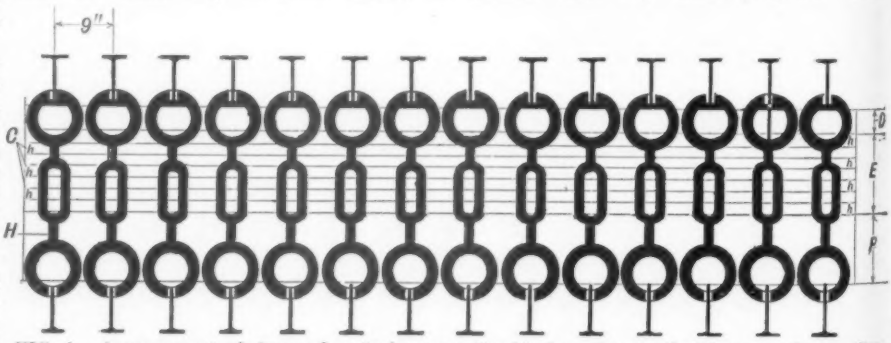

FIG. 4.—Arrangement of clamps for glueing propeller blocks. *C*, note that heavy ends are alternated. *D*, 2 in. board. *E*, laminations. *F*, block, 6 in. thick. *H*, 1 in. tie rod and turnbuckle. Each board is marked at the middle and placed on a knife edge. Heavy ends are alternated to allow for the unequal density of the wood.

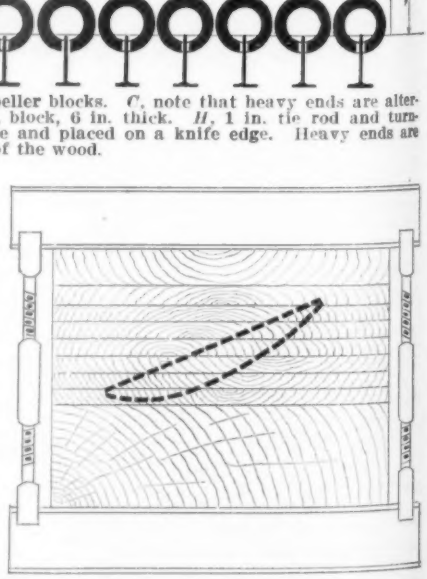

FIG. 5.—Note arrangement of boards to give edge grain on the faces of the propeller. The 2 in. board at the top should be crowned about 1/16 in. at the center to prevent excessive pressure at the edges, due to bending of the I beam when the clamps are tightened.

The fault found with it in this country is that it is heavier than Honduras mahogany and has a lower tensile strength.

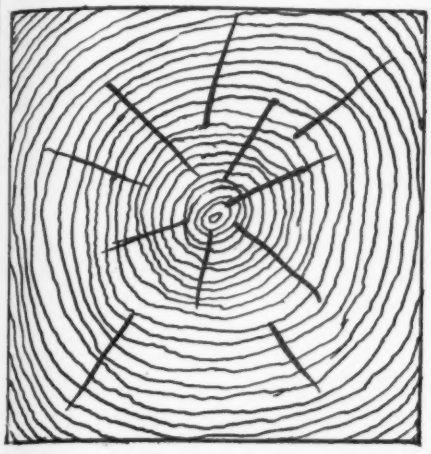

FIG. 6.—Showing the manner in which the season checks usually open up in the wood. Note that they are perpendicular to the lines of the grain.

Maple is seldom used alone on account of its extreme weight.

Seasoning of the Wood

The seasoning of the wood is, perhaps, the most important consideration in the construction of propellers. In spite of this, however, properly seasoned wood has not been available owing to the forced development of the art. For the best results the wood should be air seasoned for five years before it is used. Under present conditions one is fortunate to be able to get good material that is over two years old. To facilitate drying the wood is stacked up with small sticks between each board so that there is an even circulation of air throughout the pile.

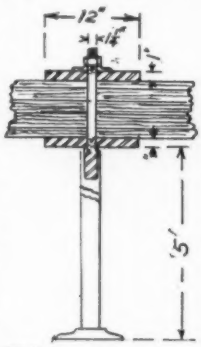

FIG. 7.—Glueing stand on which the propeller is held while the clamps are applied. Note that the hub clamp with the two flanges has a stud which fits down into the stand and which can be lifted off when the propeller is glued up.

Even after the wood is thoroughly seasoned it is best to put it through a dry kiln before glueing it up.

Figs. 1 and 2 show the principle of the construction of the dry-kiln. It will be noticed that the foul air is drawn out from the bottom. This is the proper method, as the impurities sink to the bottom.

The boards are stacked up in the kiln with sticks between and steam is turned in until the air is very damp. This opens up the pores of the wood and makes it possible for the impurities on the inside to escape. The temperature of the kiln is gradually increased until it reaches about 140° F. Meanwhile the moisture is maintained so that the wet bulb thermometer and the dry bulb thermometer show a difference of 17° F. (this corresponds to a relative humidity of 60 per cent at a temperature of 140° F.).

This operation should consume about three days. The temperature is maintained at 140° F. and the difference of temperature between the wet and dry bulb thermometers is increased to 27° F. (corresponding to a relative humidity of 43 per cent). This will require about three days more. The kiln is maintained under these conditions for about two weeks. The steam is then cut off entirely and the air is allowed to reach its greatest dryness. The wood is now allowed to dry for three or four days.

After the wood is removed from the kiln it should be stacked up in the propeller shop and allowed to stand for two or three weeks. The propeller shop should be kept at a temperature of about 80°F. and a relative humidity of about 45 to 55 per cent.

The material may now be dressed down to the thickness of the laminations. This must be done very carefully. The following thicknesses are recommended for laminations: 11/16-; ¾-; 13/16-inch. The thickness must conform to these thicknesses within 1/64 of an inch.

Lamination

The selection and arrangement of the material for lamination is the next step.

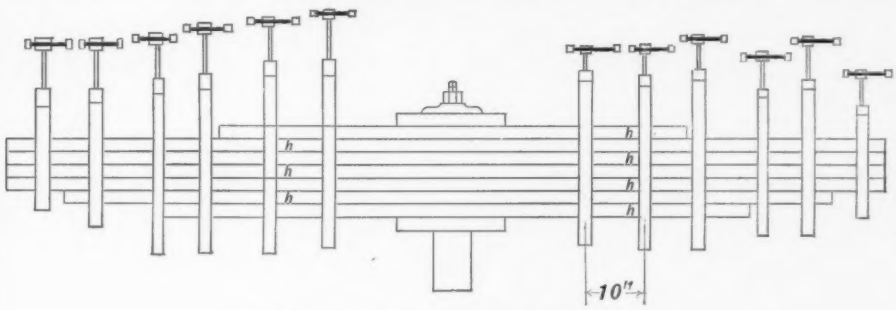

FIG. 8.—Showing rows of clamps 10 in. apart.

Before making any effort to select the pieces to be used in the propeller it is best to lay out the shape of the laminations on a drawing. A paper pattern should then be cut to the shape of the plan outline of each lamination cutting the edge of the pattern ½-inch outside of the extreme edge of the lamination. This will be made clear by Fig. 11.

In selecting the pieces of wood the pattern is laid on the board so that the grain of the wood runs along the edge of the pattern (Fig. 3) and the pattern shape is marked off on the board. All the material falling inside the mark must be absolutely free from knots, season checks, dry rot or other imperfections. In case any imperfections are found inside the mark the pattern must be shifted or the board rejected.

One method of glueing up the laminations is shown in Figs. 4 and 5, and another in Figs. 7, 8, 9 and 10.

The method of glueing the boards together in the form of a block is recommended where experienced workmen are not available. This method is shown in Figs. 4 and 5. The total pressure applied on a block ten feet long by twelve inches wide will vary from about 2,000 pounds for soft woods such as spruce to about 4,000 pounds for hard wood such as birch. Success depends on maintaining all portions of the glued surfaces in intimate contact until the glue has set. It requires more pressure to get this condition with the hard wood than with the soft. Fig. 5 shows the warp or season check if the edge grain is exposed to the surface. Examination of a few pieces of wood will show that season checks nearly always open up in the direction shown in Fig. 6 i.e. perpendicular to the lines of the grain. In practice this will be found to be quite important.

For quantity production or in any case where economy of material is important the method shown in Figs. 7, 8, 9, 10, will be used. This method requires a little more care than the one shown in Fig. 4, but equally good results may be obtained if the work is carefully done.

Glueing

The choice of the glue to be used will depend upon its reliability in practice more than anything else. Laboratory tests serve to eliminate brands that are very weak or are too readily affected by moisture. An important requirement is arrangement of the boards necessary to get edge grain. This is quite important as the wood is much less likely to

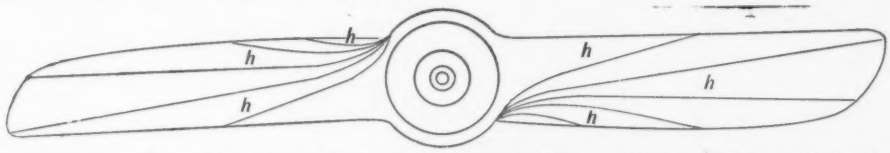

FIG. 9.—Plan view of laminations as above. Each lamination is put on an arbor and tried for balance on knife edge. The heavy ends are marked and are alternated as shown by the letter *h*. Unless this is done it will often be necessary to make one blade thinner than the other in order to balance the propeller, on account of variations in the density of the wood.

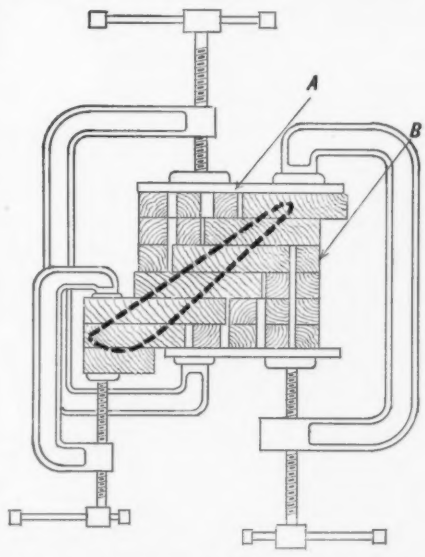

FIG. 10.—Arrangment of each row of clamps shown in Fig. 8. Note the edge grain along the dotted line which represents the finished section of the propeller. *A*, strip of maple, ⅜x1½ in. *B*, small square blocks, about 4 in. long. These are dipped in paraffine or coated with shellac to prevent the glue from sticking. It is necessary to have sets of these for each lamination thickness that is used.

that the glue shall not chill for some time after it is applied. Failures from this source are quite common in practice and, unfortunately, they cannot be eliminated by inspection. A glue that has been used with very good results by the writer is Baeder & Adamson's No. 997-W.

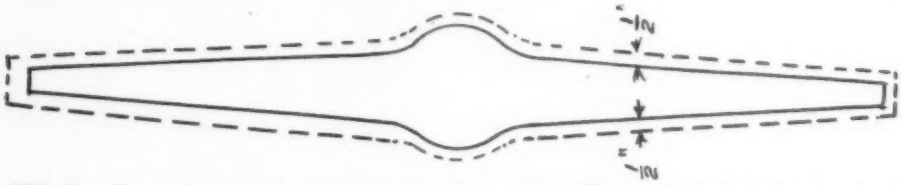

FIG. 11.—Shape of pattern for sawing out the laminations. The solid line indicates the shape obtained from the drawing and the dotted line the proper shape to saw by.

The glue should be soaked in cold water for from 18 to 24 hours and heated up gradually during three or four hours to about 160° F. (Some grades of glue require a lower temperature). Since the viscosity of the glue rather than its specific gravity determines the working qualities it is desirable to mix it to a proper consistency or thickness rather than to mix the ingredients by weight. The glue should be made up fresh each day for the best results.

Before being glued together the laminations are toothed with a toothing plane or with No. 2½ sandpaper. This gives a surface suitable for glueing. The laminations are then put in the glue room for two or three hours.

The glue room should be kept at a temperature of about 100° F. and should be provided with a steam box kept at a temperature of about 135° F.

The laminations are placed on the stand shown in Fig. 7 and are arranged in the exact way in which they are to be glued. Each lamination is marked with a pencil along the edge of the next lamination above so that it may be easily located in glueing.

The laminations are placed in the steam box for about an hour and are then ready to glue. The glue is applied to both sides of the boards. It should be applied evenly and rapidly. The whole operation of glueing should not consume more than 15 to 20 minutes for the best results.

The method of applying the clamps is shown in the sketches. After the clamps are tightened the joints should be examined to see that none of them is open.

Failures encountered in glueing should not always be attributed to the glue or to the glueing practice. No amount of care will produce a good glue joint in wood that is not properly dried and by far the greater percentages of the failures encountered where the work is carefully done can be traced to this source.

The Accuracy of Modern Aero-Tachometers

By H. N. Carlson

A series of experiments, to determine the accuracy of aero-tachometers, have been made at the Massachusetts Institute of Technology by the Electrical Engineering Department.

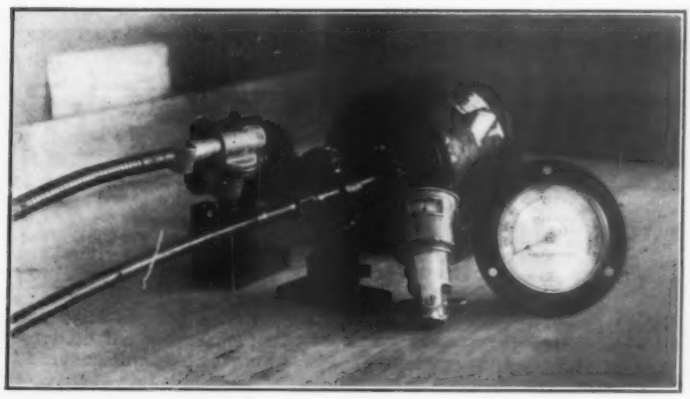

FIG. 1

FIG. 2

Tests were made on two tachometers, one manufactured by the Reliance Speedometer Company, and the other by the Stewart-Warner Company. The tachometer of the Reliance Company is of the centrifugal type, while that of the Stewart-Warner is of the magneto type. These and their driving mechanisms are shown in Fig. 1.

The tests were conducted in the following manner:

Varying temperatures from 35° F. up to 200° F. were used.

The set-up of the test is shown in Fig. 2. The two tachometers were mounted inside of a specially constructed cork box, hermetically sealed, so as to be absolutely air tight. The lower temperatures were obtained by means of a cooling mixture of calcium chloride and ice placed in the pan, shown in Fig. 2, while the higher temperatures were obtained by means of a heating coil in series with a rheostat. It was found that it was possible to keep these temperatures constant within one degree, for a period of three hours, without any trouble. In order to see the tachometers, and at the same time have the boxes completely insulated to heat, two holes were cut in the cover, these being double glass covered, one glass plate on the outside and one on the inside. In addition to these, one hole was cut in order to enable the thermometer to be read at the lower temperatures without drawing it out of the box. The glass covers and thermometer can be seen in Fig. 2.

The tachometers were driven by a quarter horsepower 110 volt direct current motor through a system of gears, which is shown in Fig. 1.

The speed of the motor was obtained by means of a ball bearing magneto carefully calibrated at various times during the test by means of a combination stop watch and revolution counter, as shown in Fig. 2. The speed of the motor was regulated by means of two rheostats, one in the field and one in the armature. This control is shown in Fig. 2. The temperature was read by means of a calibrated thermometer. One of the meters shown in Fig. 2 is an ammeter in the motor field, while the other is the voltmeter used in conjunction with the magneto.

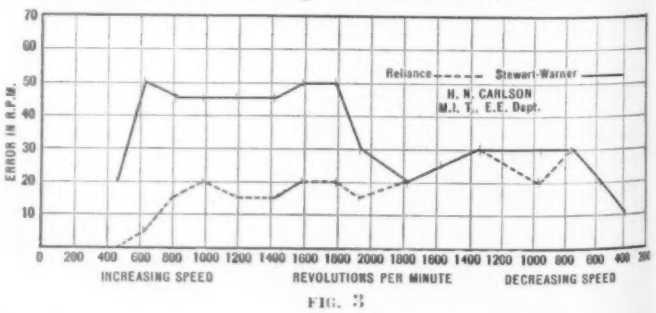

FIG. 3

The results of these tests are included in a series of correction curves at various temperatures, one of which is shown in Fig. 3.

The conclusions arrived at were that both tachometers were surprisingly accurate at all temperatures, and that, as far as accuracy is concerned, nothing more could be expected.

Course in Aerodynamics and Airplane Design*

By Alexander Klemin, A.C.G.I., B.Sc., S.M.

Instructor in Aeronautics, Massachusetts Institute of Technology, Member of the Aeronautical Society of Great Britain and Ireland,

and

T. H. Huff, S.B.

Instructor in Aeronautics, Massachusetts Institute of Technology

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PART II—SECTION 6

Worst Dynamic Loads; Factors of Safety

One of the most difficult problems in aeronautics is the estimate of the worst loads likely to come on under unusual circumstances, on which alone correct allowances for factors of safety can be based. In speaking of factors of safety, a distinction must be made between the load factor of safety and the gross factor of safety. Thus, if the load factor of safety for a certain part of the machine is four, the material employed may be so untrustworthy that an allowance for it, of say one and a half, may have to be made, bringing up the gross factor of safety to six. It is the gross factor of safety which is commonly spoken of as the factor of safety.

Conditions Under Which Heavy Loads Come on an Airplane

Heavy loads come on an airplane under so many conditions, that the following classification is probably incomplete. It is, however, all that is possible in the present stage of the art.

(*A*) In the air:
(1) in flattening out of a steep dive
(2) in heavy banking
(3) in looping
(4) in sudden gusts.

(*B*) On the ground:
(1) on landing

We shall consider these conditions one by one as far as possible.

The wing structure will meet with the greatest loads in the air. On landing, the wing structure has to meet only the shock resulting from the deceleration of its own weight which may be some 12-15 per cent of the weight of the machine, while in the air, it has to support the whole weight of the airplane and under certain conditions five or six times the whole weight. It is in the air, therefore, that the wings meet the worst conditions. The body may carry severe stresses in the air when powerful forces come into play on the rudder and elevator, but it may also be powerfully stressed on landing. For chassis design, it is only landing and taxi-ing stresses that need be considered.

(1) Flattening Out After a Steep Dive

The exact mathematical computation of stresses in such a case is not yet possible; it is, however, interesting to see how such stresses arise, and how they are limited.

In order to have a concrete case, we will consider the Clark model tested at the Massachusetts Institute of Technology, and described in Hunsaker's "Dynamical Stability." This had the following estimated characteristics:

Wing area including ailerons	464 sq. ft.
Span	40.2 ft. mean
Area, stabilizer	16.1 sq. ft.
Area, elevators	16.0 sq. ft.
Area, rudder	9.35 sq. ft.
Length, body	24.5 ft.
Weight (tanks half full)	1600 lb.
Radii of gyration	5.2 ft. in roll 4.65 ft. in pitch 6.975 ft. in yaw
Brake horse-power	110
Maximum speed	87 m.p.h.
Minimum speed	35 m.p.h.
Best glide	1 in 9

For a tail setting of —5 deg. to the wings, the model (1/26th full size) had the following forces acting on it at a speed of 30 m.p.h., which we shall use without correction for transferring to the full size machine:

Angle	Lift on model at 30 m.p.h.	Drift on model at 30 m.p.h.
—4	—.115	+.128
—2	+.112	+.108
—1	+.240	+.104
0	+.360	+.101
+1	+.490	+.102
+2	+.625	+.105
+4	+.872	+.115
+8	+1.305	+.153
+12	+1.568	+.213
+16	+1.640	+.370
+18	+1.580	+.498

In the U. S. Army Specifications 1002 (reprinted in AVIATION AND AERONAUTICAL ENGINEERING of November 1, 1916, one of the stipulations for airworthiness is that the pilot may be required to dive at an angle of 50 deg. to the horizontal, to maintain such a dive for one or two seconds, and then to pull out reasonably quickly. We will assume that the dive is continued for even a longer period so that the limiting velocity is reached, and then try to see what will happen on flattening out sharply.

The propeller thrust on the dive may be neglected whether the engine is cut off or not, the slip being so enormous as to reduce it to a negligible quantity.

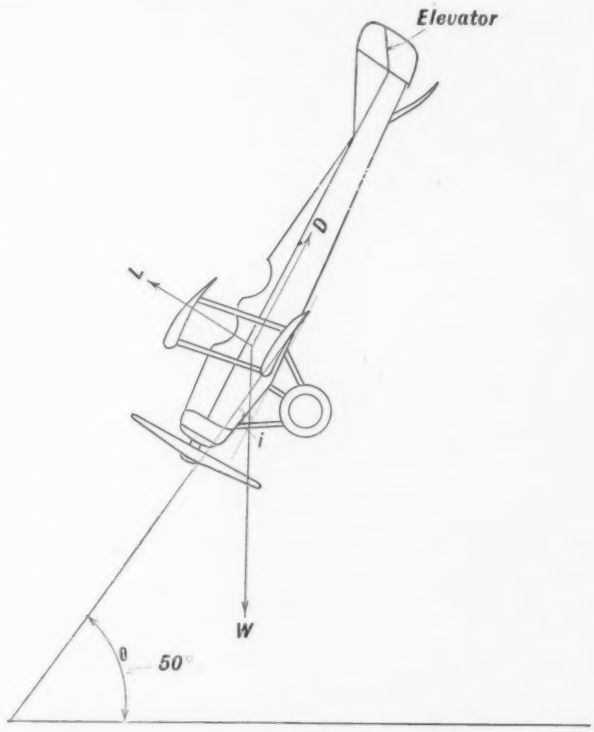

FIG. 1

Considering the sketch of Fig. 1, the equations of motion evidently are

$$D = W \sin \theta$$
$$L = W \cos \theta$$

* This Course commenced in the August 1, 1916, issue of AVIATION AND AERONAUTICAL ENGINEERING will be completed in 24 issues.

The most straightforward way of finding at what incidence to the flight path the machine is under steady limiting conditions, is one of trial and error. After one or two trials, we find that the angle of incidence, 2¼ deg. will satisfy conditions.

The drag on the model at this angle is 0.111 lb., and the lift 0.094 lb. at 30 m.p.h. The two equations are very nearly satisfied. Thus converting to full size conditions:

(1) $W \sin 50 \text{ deg.} = (1600)\ (0.7660) = 0.1235 = \frac{0.111 \times 26^2}{30^2} V^2$ and $V^2 = 14{,}850$, $V = 122$ m.p.h.

(2) $W \cos 50 \text{ deg.} = (1660)\ (0.06428) = 1030$ while $\frac{0.094 \times 26^2}{30^2} \times 0.14850 = \text{Lift} = 1040$ lb.

the difference of 10 lb. in the lift being negligible.

If, at this point, the pilot throws his elevator hard up, he will increase his angle of incidence rapidly, and move his path more and more to the horizontal. The rapidity with which he can come out of the dive depends on the force which he can bring to bear on the elevator, and is resisted by the inertia of the machine, and the damping against angular rotation. There is reason to believe that during this process he loses very little speed. The equations of motion during this process are somewhat complicated and cannot be solved directly. But if we assume that for a machine of this type, the pilot can change his angle of incidence to say 8 deg. without losing speed, the lift on the model at this speed being 1.305, the lift on the machine becomes

$$\frac{1.305}{30^2} \times 26^2 \times 122^2 = 14{,}400 \text{ lb.}$$

or a load of nine times the weight of the machine. It is commonly accepted that the actual load is not quite so great, being between 5 and 6. The pilot could not easily wreck a machine with moderately strong controls, and weights distributed far from the center of gravity giving a large moment of inertia. But with a light machine, with weights close to the center of gravity and a powerful elevator, a reckless recovery would be highly dangerous.

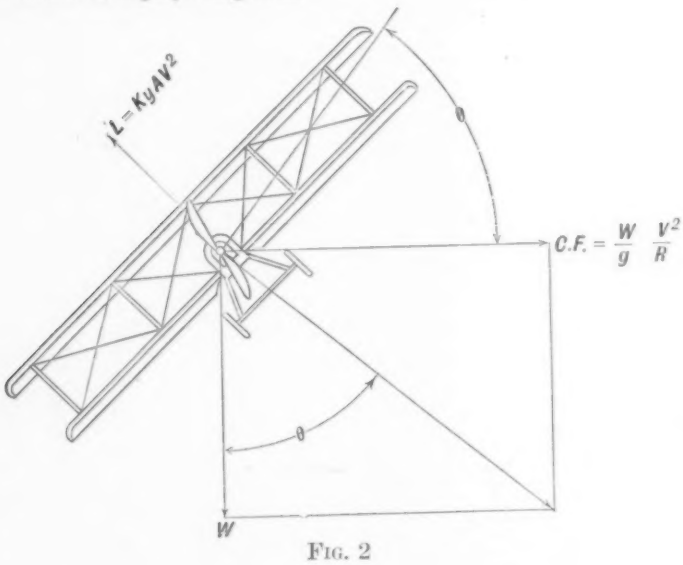

FIG. 2

It should be pointed out that the uncertainty as to the exact movements a machine goes through on flattening out, makes the question of the angles of incidence at which loads on front and rear spars should be distributed and computed a very controversial one. The latest U. S. Army specifications call for a stress diagram at 15 deg., which throws the greater load on the front spar. If, as is quite possible, a machine flattening out after a steep dive does not reach such a high angle of incidence, but arrives at some intermediate angle such as the 8 deg. mentioned above, then it would be fairer to draw a stress diagram at this angle of incidence, with a more equal distribution between the two spars.

(2) Loading in Heavy Banking

The loading on a steep bank is dependent on the speed, radius of turn, and angle of bank.

In the sketch, Fig. 2, the machine is moving out of the plane of the paper and turning at an angle of bank θ. The three forces acting in the vertical plane of the machine are the lift, the weight and the centrifugal force, which may be assumed as acting at the center of gravity of the machine. Resolving L along the lines of these two forces, we have as equations of equilibrium

$$L \sin \theta = K_y A V^2 \sin \theta = \frac{W}{g} \frac{V^2}{R}$$

$$L \cos \theta = K_y A V^2 \cos \theta = W$$

where V = speed in feet per second, and R = radius in feet. From these equations, one important fact appears, that on a steep bank where $\cos \theta$ is small, the lift of normal flight is insufficient, and that before banking a pilot must increase his power and speed, otherwise his machine may drop on the bank.

The load on the machine in banking will increase with the centrifugal force to be overcome in addition to the weight, and is, therefore, greatest when the velocity has increased beyond the maximum in normal flight and when the radius of turn is very small.

For the Clark model previously considered, we will assume that the machine has attained a speed of 120 m.p.h. or 176 ft. per second, after a dive and that the pilot goes into a sharp turn of 400 feet radius.

From the equations of equilibrium we have

$$\tan \theta = \frac{\frac{W}{g} \frac{V^2}{R}}{W} = \frac{V^2}{gR} = \frac{30{,}500}{32.2 \times 400} = 2.37$$

$\theta = 67$ deg. and $\sec \theta = 2.559$, which is certainly a fairly steep angle of bank. Since $L \cos \theta$, $L = \sec W = 2.559\ W$.

It is possible to consider a case where the velocity would be still greater than the 120 miles per hour, and the radius still smaller, in which case the loading might still be heavier. It does not seem probable, however, that the worst possible loading on a bank would exceed 3 or 4 W.

The angle of incidence on a bank interests us again from the point of center of pressure and distribution of pressure between the two spars. Considering the Clark model of the previous paragraph, $W = 1600$ and $L = 2.559\ W = 4100 = K_y \times 464 \times 120^2$

from which $K_y = \frac{4100}{464 \times 14{,}400} = 0.000615$

and the angle of incidence is not much above 0 deg. for the Clark machine on such a bank.

(3) Loading in Looping

In looping similar methods would be employed as in considering flattening out after a dive. The probable maximum loading is estimated to be 4.

(4) Stresses Due to Gusts

Another cause of violent stresses is in the action of sudden gusts on a machine, where the inertia tends to maintain the same speed for a different angle of incidence, or the same incidence for a different speed.

The machine may encounter:

(a) a head-on gust
(b) a following gust
(c) an up-gust
(d) a down-gust.

Granted a sufficiently violent gust, there is no possible limit to the stresses which may come on a machine in such cases, and a hurricane might wreck a machine for whatever factor of safety it was designed. It is necessary to investigate, however, whether the gusts, as we may expect to occur in ordinary practice from our metereological data, are well within safe limits.

(a) Head-on Gusts

Imagine the Clark machine to be moving at 59 m.p.h. at an angle of incidence 2 deg. against a head-on wind of 20 m.p.h. so that its absolute velocity relative to the earth is 39 m.p.h. If the head-on wind increases to 30 m.p.h., the absolute velocity relative to the earth will still remain at 39 miles for a second or two. During this period, the velocity to the air will increase to 69 miles per hour, with the angle of incidence unchanged. The lift on the machine will, therefore, be momentarily increased in the ratio of $\frac{69^2}{59^2} = 1.36$.

There will be an acceleration upwards and an increased load on the machine = 1.36 W.

(b) Following Gusts

If the machine were traveling in a following wind, which

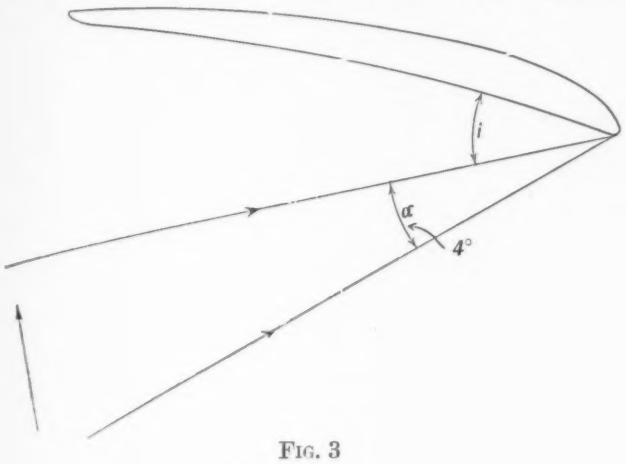

FIG. 3

suddenly diminished, a similar action would ensue, since the relative velocity to the air would here also increase.

If, on the other hand, in the case considered above the head-on gust suddenly diminished to 10 miles an hour, the relative velocity to the air would be decreased to 49 miles per hour, and the lift would be diminished in the ratio of $\frac{49^2}{59^2} = 0.69$ and the lift on the wings would, in this case, be actually less than in normal flight, so that the machine would drop.

It is also clear from the above that the gust effects are most important, when the speed of the machine is lowest.

(c) Up-gusts; (d) Down-gusts

Without going into numerical examples, we can see easily from Fig. 3, the effect of an up-gust in increasing the load. The up-gust both increases the velocity of the relative wind and its angle of incidence, with a corresponding increase in lift, except at very high angles where a reverse effect is possible. For a down-gust the converse would hold true.

With normal flying weather, the effect of gust should never increase the load to more than two or three times the weight of the machine.

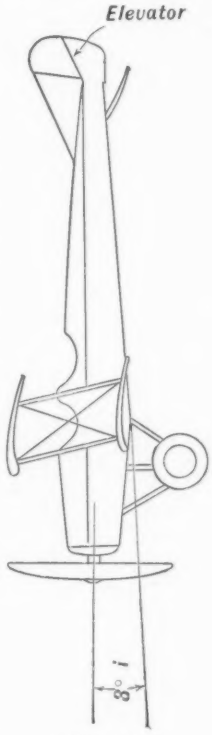

FIG. 4

Limiting Velocity for a Sheer Vertical Dive

A sheer vertical dive is unlikely to occur and is not required for stress calculations in practice, but it is interesting to note the extreme limiting velocity in such a case. A sheer vertical dive is only possible if the machine is at the angle to the vertical which gives no lift, and the elevator is set only at such an angle that the moment of the total drag about the center of gravity is neutralized.

For the machine in question the angle of no lift is —3 deg. The drag on the model at this angle is 0.118 lb. To find the limiting velocity, we can write

$$W = 1600 = \frac{0.118 = 26^2}{30^2} \times V^2$$

from which V = 134 m.p.h., which is not so very much greater than the limiting speed on the 50 deg. drive.

Worst Loads on Landing

The computation of such loads is connected with chassis design, and we shall deal more fully with it later. Some calculations taken from "Notes on Aeroplane Shock Absorbers of Rubber" are an interesting introduction to the subject:

An airplane weighing W pounds striking the ground at V feet per second on a glide of 1 in 7 has kinetic energy to be absorbed by the landing gear of $\frac{W}{2g}\left(\frac{V}{7}\right)^2$. If the machine comes o rest after a motion of x feet, the work done by gravity on it is Wx, and the total stored in the shock absorber is $W\left\{x + \frac{1}{2g}\left(\frac{V}{7}\right)^2\right\}$. The average force in the springs is half the maximum F, given by the equality:

$$\tfrac{1}{2}Fx = Wx + \frac{1}{2g}\frac{V^2}{7}$$

or

$$F = W\left\{2 + \frac{1}{xg}\left(\frac{V}{7}\right)^2\right\}$$

If we take ordinary conditions as V = 66 ft. per sec. (45 m. p. h.) $F = W\left(2 + \frac{5.7}{x}\right)$, from which we get the following table for use in design:

x	F
1 in.	68 W
3 "	23 W
4 "	17 W
5 "	13.7 W
6 "	11.5 W
8 "	8.6 W
10 "	6.8 W
12 "	5.7 W

It appears that the load on the landing gear is nearly 14 times the weight of the airplane, if a motion of only 5 in. is allowed. This requires an excessive factor of safety and makes a very heavy construction. Of course, no allowance has been made for the collapse of pneumatic tires which may add 2 in. to the motion of the recoil mechanism.

References—Part 11, Section 6

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Mr. Akimoff Asks for Suggestions from Engineers

AVIATION AND AERONAUTICAL ENGINEERING has received the following letter. We hope those who are interested will respond to the request:

"I am completing a text book on Applied Hydrodynamics, meant mostly for aerodynamic problems, etc.

The book will go to press probably in July; it will be of the same general character and meant for the same grade of engineers as my recent book, "Lagrange's Equations."

Should there be any topics, which, in your judgment, should be especially well worked out in detail, I should be glad to hear from you regarding the same.

Thanking you in advance, I am

Yours very truly,

(Signed) N. W. AKIMOFF."

1013 Harrison Building,
Philadelphia, Pa.

Aeronautical Patents

ISSUED APRIL 17, 1917.

1,223,315. Filed November 22, 1913. To Glenn H. Curtiss, Hammondsport, N. Y., assignor to the Curtiss Motor Co., Hammondsport, N. Y. Landing Gear for Aircraft.

1,223,317. Filed December 11, 1914. To Glenn H. Curtiss, Hammondsport, N. Y., assignor to the Curtiss Motor Co., Hammondsport, N. Y. Folding Wing Aeroplane.

1,223,330. Filed September 19, 1916. To Frederick Henry Royce, assignor to Rolls Royce, Ltd., Derby, England. Aircraft Propeller.

1,222,939. Filed April 21, 1916. To Perry Lorenzo Eddy, Cripple Creek, Colo. An Airship.

ISSUED APRIL 24, 1917.

1,223,698. Filed Jan. 18, 1916. To Carl Alfred Johansson, Christiania, Norway, Stabilization of Aircraft.

1,223,940. Filed Aug. 29, 1908. To William S. Cranmer, Fresno, Cal. Flying-Machine or Flier.

Two Hundred Books on Aeronautics

By E. N. Fales

In Charge; Aeronautics, University of Illinois

Of the one or two thousand existing books on aeronautics only a few are of real value; it is estimated that over 80 per cent of the total number may be disregarded by students. This was found to be the case in establishing the comprehensive aeronautical collection of the University of Illinois library; for by culling out the books of little value it has been possible to cover the field with a comparatively small list of titles. Thus the cost of a comprehensive library need not be $2,400, which price would be needed to purchase a copy of every existing book, but may be reduced to about $350.

The obvious reason why so many books are practically valueless is that since the European war rapid developments have occurred such as to make obsolete many early designs and theories. Again there is much overlapping of material between different authors, and even in the reduced list of 200 books many of them contain only a few pages that repay study.

Below are given two lists of aeronautical works. The first, numbering twenty-three titles is for designers' use and contains only technical data and other up-to-date information. The second list of 200 titles includes the first and is based upon it as a nucleus.

List of Books for Designers

"Aerodynamics" ..... Lanchester.
"Aerodonetics ..... Lanchester.
"Aeroplane," 3rd Ed ..... Fage.
"Air Screws" ..... Riach.
"Fliegerhandbuch" ..... Eyb.
"Flight without Formulae" ..... Duchene.
"Hydrodynamics" ..... Lamb.
"Mechanics of the Aeroplane" ..... Duchene.
"Military Aeroplanes" ..... Loening.
"Mechanical Engineer's Handbook" ..... Marks.
"Nouvelles Réchérches sur la Resistance de l'Air et Aviation" ..... Eiffel.
"Resistance of the Air and Aviation" ..... Eiffel-Hunsaker.
"Four Technical Reports of the Advisory Committee for Aeronautics" ..... Great Britain.
"Two Reports of the Advisory Committee for Aeronautics" ..... United States.
"Stability in Aviation" ..... Bryan.
"Stress Considerations in Aeroplane Design" ..... Zahm.
"Wing Data and Analysis for Staggered Biplane" ..... Zahm.
"Royal Training Corps Flying Manual" ..... Great Britain.

List of 200 Books for Aeronautical Library

Many of the foreign books listed are not now available due to European War Censorship

Laboratory Reports Giving Experimental Data

"Artificial and Natural Flight." Hiram Maxim. N. Y., 1908, Macmillan Co. (Treats of Maxim's elementary experiments on wings and propellers also of his full-scale experiments.)

"Bulletin de l'Institute Aérodynaminque de Koutchino," Riabouchinski. Bulletins No. 1-3, 1906-1909. Moscow, Russia, I. N. Kouchnereff & Cie, Pimenovskaïa 12.

"Dynamical Stability of Aeroplanes," J. C. Hunsaker. Washington, 1916, Smithsonian Institution. (Mathematical and experimental treatise on balance, oscillations, damping, etc., of modern aeroplanes, with conclusions.)

"Essais d'Aérodynamique," A. de Gramont duc, de Guiche. Paris, 1911. Hatchette et Cie. (One of three publications of the de Guiche laboratory, representing wing tests made by mounting wings above a moving automobile.)

"Expériences et Mesures sure l'Aéroplane en Plen Vol," J. Legrand. Paris, 1914, Librairie Aeronautique. (Account of experiments of various investigators. Reprint from records of Soc. Eng. Civils de France.)

"Experiments in Aerodynamics," S. P. Langley. Washington, 1902, Smithsonian Institution. (Second edition of report originally published in 1891 describing Langley's experiments with whirling table apparatus.)

"L'Institut Aérotechnique à St. Cyr de l'Université de Paris." All bulletins published to date. Paris, Dunod et Pinat.

"Nouvelles Réchérches sur la résistance de l'Air et l'Aviation. Faites au Laboratoire d'Anteuil," G. Eiffel. Paris, 1914 (2 vols.). Dunod et Pinat. (Treats of Eiffel's latest experiments in his enlarged wind tunnel at Anteuil. One of the most important available works on matters of aeroplane design.)

"Récherches Experimentales sur la Résistance de l'Air, Executeés à la Tour Eiffel," G. Eiffel. Paris, 1907, L. Maretheux.

"Rendiconte delle esperienze e degli studi eseguiti nello stabilemente de esperienze e construzioni aeronautichi del genio." Published by Cav. V. Salviucci, Violi Giulius Caesare No. 2, Roma.

"Report on European Aeronautical Laboratories," A. F. Zahm. Washington, 1914. Smithsonian Insti. (Brief description of leading European aerodynamical laboratories.)

"Reports on Tunnel Experiments in Aerodynamics," J. C. Hunsaker et al. Washington, 1916. Smithsonian Insti. (Mathematical and experimental treatises on various features of aeroplane design.)

"First Annual Report of the National Advisory Committee for Aeronautics," U. S. Washington, 1916, Govt. Printing Office. (Containing reports from various sources especially prepared on such subjects as aeroplanes in gusts, wires, atmosphere, aircraft fabrics, aero engines.)

"Second Annual Report of the National Advisory Committee for Aeronautics," U. S. Washington, 1917, Govt. Printing Office. (Contributions from various sources bearing on the present status of aeronautics in the U. S.)

"Technical Reports of the Advisory Committee for Aeronautics," Great Britain. London, 1910 for 1909-10 report, 1911 for 1910-11 report, 1912 for 1911-12 report, 1914 for 1912-13 report, Wyman & Sons. (These reports are the most valuable publications on aeronautics at present available, giving results of a wide variety of laboratory tests on aircraft and aircraft parts, and applying these results to design use. Data is of the following general classifications: Air forces on models of airships, airplanes, wings, struts, bodies, wires, wheels, etc. Strength of materials, alloys; characteristics of balloon fabrics; stability moments, propellers, full scale experiments, wind tunnels.

"Resistance de l'Air," G. Eiffel. Paris, 1910, Dunod et Pinat. (Treats of various early laboratory experiments, including Eiffel's Champ de Mars Laboratory.

"Resistance of a Plane Surface in a Uniform Current of Air," 1904–"Experiments on Wind Pressures," 1907-8, T. E. Stanton. London, 1904 and 1908, Inst. Civil Engineers. (Early experiments made at the National Physical Laboratory, Teddington, England.)

"The Resistance of the Air and Aviation," G. Eiffel. N. Y., 1913, Houghton Mifflin Co. (Translation by J. C. Hunsaker or Eiffel's 1911 Report on wind tunnel tests. This and Eiffel's later report are the basis of French technical aerodynamics. Treats of the characteristics of wings, airplane models, propellers, etc.)

"Theoretische und Experimentelle Untersuchungen an Ballonmodellen." George Fuhrmann. Berlin, 1912. Julius Springer.

"Uber die Statische Langstabilität der Drachenflugzeuge," Carl Wieselberger. Berlin 1913, Königl Technische Hochschule zu München. (Wind tunnel experiments.)

Design of Airplanes

"Aeroplane Design," Lt. F. S. Barnwell. London, 1916, McBride, Nast & Co. (Elementary Lecture on General Layout and Balance of an Aeroplane. Bound with "Simple Explanation of Inherent Stability," by W. G. Sayers.)

"The Aeroplane," A Fage. London, 1917, Third Ed., Chas. Griffin & Co. (Third Edition brought up to date Dec. 1916, contains as appendices: (1) A graphical method of calculating aerodynamical performance of an aeroplane; (2) a table of the results of some experiments on the skin friction of various surfaces; (3) miscellaneous design data. "The Aeroplane" is a concise introduction to aeronautical engineering based on aeronautical data of the National Physical Laboratory, treating of construction, stability, propeller, engine.)

"Army Military Aeroplane Competition of 1912." Report of Judge's Committee. London, 1912, T. F. Unwin.

"Design of Aeroplanes," A. W. Judge. London, 1916, Whittaker & Co. (Collection of tables and diagrams taken from Technical Reports of the Advisory Committee for Aeronautics, and elsewhere.

"Fliegerhandbuch, Ein Leitfaden der Gesamten Flugtechnik," R. Eyb. Berlin, 1914. R. C. Schmidt. (Excellent book for designer, containing clear diagrams and treatment of experimental aerodynamics, meteorology, construction, engines, propellers, with 70 pages on operation of controls in flight.)

"Handbuch für Flugzeug-Konstrukteure; Eine Ubersichtliche Anleitung zur Berechnung und zum Bau," Cammillo Haffner. Berlin, 1913, R. C. Schmidt. (Useful for designers; treats of automatic stabilizers; contains construction diagrams.)

"Hilfsbuch Für Den Flugzeugbau," O. L. Skopik. Berlin, 1913. R. C. Schmidt.

"Leitfaden der Flutechnik," Siegmund Huppert. Berlin, 1913. J. Springer. (Contains interesting treatment of stability, motors, propellers in theory and practice. Many construction diagrams.)

"Military Aeroplanes," Grover C. Loening. Boston, 1916. W. S. Best Co. (General Principles of Design and Present Practice in U. S.)

"Properties of Wing Sections and Resistance of Bodies." Whittaker's Specialist Series Vol. II. (Not yet published.) London, Whittaker & Co.

"Stress Considerations in Aeroplane Design," A. F. Zahm. 1913.

"Wie Berechnet, Konstruiert und Baut Man ein Flugzeug?," O. L. Skopik. Berlin, 1912, R. C. Schmidt. (Contains construction diagrams.)

"Wing Data and Analysis for a Staggered Biplane," A. F. Zahm. J. B. Lippincott, 1914. (Method of determining strength of wings. Reprint, proc. Franklin Institute.)

Theoretical and Technical Aerodynamics

"Abrisz der Lebre von der Flussigkeit und Gasteuregung," Prandtl.

"Aérodynamique — Bases Théoréques de l'Aéronautique," Jonkeuski. Paris, 1916, Gauthier-Villars.

"Die Gesetze des Wasser und Luft," O. Martienssen. Widerslauder, 1913.

"A Discussion Concerning the Theory of Sustentation and Expenditure of Power in Flight." F. W. Lanchester. Birmingham, 1915. Paper presented at International Engrg. Congress, Sept. 20-25, 1916, San Francisco.

"Dynamics of Mechanical Flight," Sir Geo. Greenhill. London, 1912, Constable & Co. (Lectures delivered 1910 and 1911 at the Imperial College of Science and Technology—Elementary theory of fluid dynamics.)

"Flight without Formulae," Duchêne. London, 1914. Longmans Green. (Translation by Lederboer of a French text book of elementary airplane theory, published 1913 in France.)

"Hydrodynamics," A. S. Ramsey. (Theory of Fluid Dynamics.)

"Mechanics of the Aeroplane," Capt. Duchêne. London, 1915, Longmans Green. (Translation by Lederboer & Hubbard of a French text book on airplane theory.)

"Naval Architecture," Peabody.

"Naval Architecture," White.

"Speed and Power of Ships," Taylor.

"Stability and Equilibrium of Floating Bodies," B. C. Laws. N. Y., 1914, D. Van Nostrand.

"Uber die Lage des Aerodynamischen Druchmittel Punktes and Ebenes und Gewolbten Flächen." Inaugural Dissertation, R. Benitt Kiel, 1912, Ludke & Martens.

"Versuche an Doppeldeckern zur Bestimmung Ihrer Eigengeschwindigkeit und Flugwinkel," Wilhelm Hoff. Berlin, 1913. J. Springer.

"Vorlesungen über Hydrodynamik und Gasdynamik," L. Prandtl.

Gasoline Aeronautical Engines

"Aero Engines," G. Burls. London, 1915, C. Griffin & Co. (With introductory account of the theory of the internal combustion engine.)
"Gasoline Automobile Vol. 1, Gasoline Motors," Heldt.
"Gas Petrol and Oil Engines," Vol. II, Clerk & Burls. London, 1913, Longmans Green. (Half the book treats of gas engines, half of liquid fuel engines.)
"Gas and Oil Engines," Marks and McDewell. Chicago, 1916, American School of Correspondence. (Vol. I contains general theory of explosion motors and an excellent treatise on carburetors; Vol. II treats of gas engines and high speed automobile engines; Vol. III treats of ignition, timing, operation.)
"Moteur Gnome," Audreé Preynat. Paris, 1913, Dunod et Pinat.
"Motors for Aeronautical Purposes." Alexander Prize Motor Competition. London, 1911, H. M. Stationery Office.
"Motoren für Flugzeuge und Luftschiffe," Fritz Huth. Berlin, 1914, R. C. Schmidt. (Treats of the fundamental practical considerations in aero engine design, with diagrams and many photographs. A good book but old.)
"Reports on the Competition for the German Chancellor's $20,000 Aero Engine Prize," 1912. (Published in "Zeitschrift des Vereines Deutchen Ingenieure." January to June, 1913, pages 481, 692, 801. See also pages 372, 583. These articles are considered an authority in America.)

Mathematical Treatment of the Theory of Aviation

"Aerodynamics, Constituting the First Volume of a Complete Work on Aerial Flight." F. W. Lanchester. London, 1907, A. Constable & Co.
"Aerodonetics, Constituting the Second Volume of a Complete Work on Aerial Flight," F. W. Lanchester. London, 1910, (Second Ed.), Constable & Co. (These two large volumes form the basis of much of the later mathematical and analytical treatment of technical aerodynamics.)
"Etude de la Stabilité de l'Aeroplane," Geo. de Bothezat. Paris, 1911. Dunod et Pinat.
"Stability in Aviation," G. H. Bryan. London, 1911, Macmillan & Co. (The author has succeeded in putting airplane stability on a mathematical basis.)
"Theorie Générale des Regimes de l'Aeroplane," Geo. de Bothezat. Paris, 1913, Dunod et Pinat.
"Report on the theory of a stream line past a plane barrier and the discontinuity arising at the edge, with an application of the theory to an aeroplane." Sir G. Greenhill. London, 1910, H. M. Stationery Office. (Adv. Comm. for Aeronautics (Gt. Britain) Reports and Memoranda No. 19.)

The Gyroscope

"Theory and Operation of the Gyroscope, and the Sperry Gyroscopic Compass," Ensign B. E. Gelling, U. S. A. (Reprint from U. S. Naval Proceedings, Vol. 38, No. 2. Whole No. 142.
"Engineering Application of the Gyroscope," Elmer A. Sperry. (Reprint from Journal, Franklin Institute, May, 1913, J. B. Lippincott.)
"Report on Gyroscopic Theory," Sir Geo. Greenhill. London, 1914, H. M. Stationery Office. (Reports and Memoranda, Advisory Commission for Aeronautics, Great Britain.)

Airplane Propellers

"Airscrews," M. A. S. Riach. London, 1916, Crosby, Lockwood & Son. (Excellent and clear treatise on working theory.)
"Luftschrauben-Untersuchungen," F. Bendemann. Munich, 1912, R. Oldenbourg.

Seaplanes

"Les Hydro-Aéroplanes," F. R. Petit. Paris, 1912. Dunod et Pinat. (Theory and illustrations.)
"Les Hydro-Aéroplanes," P. Riviere. Paris, 1913, Librairie Aéronautique. (Contains illustrations; no theoretical treatment.)
"Die Wasserdrachen; Ein Beitrag zur Baulichen Eutwichlung der Flugmachine," Joseph Hofmann. München, 1913, R. Oldenbourg. (Contains theory and illustrations; treats of complications due to waves.)

Operation of Airplanes

"The Airman," C. Mellor, 1913. (Experiences while obtaining a pilot's license in France.)
"Der Bleriot-Flugapparat und Seine Benutzung durch Pegoud," P. Bejeuhr. Braunschweig, 1914, Friederich & Sohn.
"Erecting and Aligning an 80 H. P. Avro Biplane Type 504." Manchester, 1915, A. V. Roe & Co., Ltd.
"Essays of an Aviator." London, "Aeronautics," 170 Fleet Street.
"Le Pilotage d'un Aéroplane," P. Banet-Rivet. Paris, 1912, Gauthier-Villars.
"Stability of Aeroplanes," Orville Wright. Washington, 1915, Smithsonian Institution. (Reprint from Journal Franklin Inst., Sept., 1914.)

Balloons and Dirigibles

"All About Zeppelins," Kegan Paul French.
"Anlage und Betrieb von Luftschiffhäfen," Christians. München, 1914, R. Oldenbourg. (Dirigible maneuvers, hangars, etc.)
"Astra Castra: Experiments and Adventures in the Atmosphere," Hatton Turner. London, 1865, Chapman & Hall. (This volume is the classic of ballooning literature.)
"Le Ballon Libre." Paris, 1911, Librairie Aéronautique. (Useful treatment of the free balloon, practical and theoretical.)
"Etude sur la Dynamique des Ballons Libres," Degouy. Paris, 1902-3, Berger Levrault & Cie.
"Guide de l'Aéronaute Pilote," Paul Renard. Paris, 1910, Dunod et Pinat. (Treats of free balloons.)
"La Navigation Aérienne, l'Aviation et la Direction des Aérostats dans les Temps Anciens et Moderns," Gaston Tissandier. Paris, 1886, Hatchette et Cie.
"Prall-Luftschiffe-Bau und Betrieb von Prall-Luftschiffe," Richard Basenach. Frankfurt, 1912, Aufforth, Co.
"Theory of Ballooning," Reber.
"Travels in the Air," James Glaisher. London, 1871, R. Bentley.

Military Uses of Aircraft

"Aircraft in War and Peace," W. A. Robson. London, 1916, Macmillan & Co. (Popular treatise.)
"Airships in Peace and War," R. Hearne. London, 1910, J. Lane.
"Navy League Annual 1915-1916," Robt. Yerburgh. (Great Britain) London, 1916, J. Murray.
"Für Mein Vaterland! Das gegenwärtige Militär Flugwesen und die Militärluftschiffahrt der Europäischen Grossmächte," Willy Hahn. Berlin, 1913, C. J. E. Volckmann.
"Etat Actuel de l'Aéronautique Militaire et Navale en France et à l'Etranger." Paris, 1914, Librairie Aéronautique.
"Sea, Land and Air Strategy, a Comparison," Sir Geo. Aston. London, 1914, J. Murray.
"Aircraft in the Great War," Grahame-White and Harper. London, 1915, T. F. Unwin.
"Equipment for Aero Units of the Aviation Section" (Tentative). Washington, 1916, U. S. Gov't. Printing Office. (List of equipment, tools, cost estimates, etc.)
"Manual for Aero Companies," H. M. Satterfield. Buffalo, 1916, Jesse Kittinger & Co. (Digest and reprint of the Royal Flying Corps training manual.)
"Training Manual Royal Flying Corps" (Provisional). Parts I and II. London, 1914, T. Fisher Unwin. (Part I. Care and operation of army aeroplanes. Part II. Military Organization of R. F. C. and methods of employing aeroplanes.)
"Aeroplanes and Dirigibles of War," Frederick A. Talbot. London, 1915, W. Heinemann.
"Some Engineering Details of Military Aviation," T. F. Dodd. Urbana, Ill., 1915, University of Illinois Thesis.
"Aircraft in Warfare, the Dawn of the Fourth Arm," F. W. Lanchester. London, 1916, Constable & Company.
"Air War and How to Wage It," N. Pemberton Billing.
"Tales of the Flying Service," C. G. Grey.
"In the Royal Naval Air Service," London, E. & F. Spon.
"Aircraft in War," E. S. Bruce, London, 1914, Hodder & Stoughton. (The Daily Telegraph War Books.)

General and Historical Books of an Elementary Nature

"Aerial Navigation," A. F. Zahm. New York, 1911, D. Appleton & Co. (A popular and entertaining treatise on the development of mechanical flight.)
"Aéro Manuel: Repertoire sportif, technique, et commercial de l'Aéronautique," Faroux & Bonnet. Paris, 1914, Dunod et Pinat. (Comprehensive volume treating of the history, sports, technical and commercial side of aeronautics; with many illustrations. tables and technical notes, the latter chiefly taken from Eiffel.)
"Aeronautical Annual," James Means. Boston, 1895, 1896, 1897, W. B. Clarke & Co. (Three volumes containing articles by authorities of the time, and repesenting the state of the art at that time. Excerpts published in 1910 in a fourth volume, "The Epitome of the Aeronautical Annual.")
"Aeronautical Classic." London, Aeronautical Society of Great Britain. (Comprises historical treatises as follows: "Aerial Navigation," Sir Geo. Cayley; "Aerial Locomotion," Wenham; "Art of Flying," T. Walker; "Aerial Ships," Lana; "Gliding," Percy Pilcher and Stringfellow; "Flight of Birds," Borelli.
"L'Aéronautique Navale Militaire Moderne, France et l'Etranger," Ch. Lafon. Paris, 1914, Dunod et Pinat.
"Aviation," A. E. Berriman. London, 1913 Methuen & Co. (Second Edition.) (An introduction to the elements of flight.)
"Aviator's Companion," Dick and Henry Farman. London, 1910, Mills & Boon. (Interesting personal experiences of the authors.)
"Airships Past and Present," A. Hildebrandt (Capt. in Prussian Balloon Corps). London, 1908 (Trans. from the German by W. H. Story), Archibald Constable & Co. (Treats of balloons and dirigibles in a popular way.)
"Aircraft in the Great War," Claude Graham and Harry Harper. London, 1915, T. F. Unwin. (Popular description of military uses of aircraft.)
"All the World's Aircraft, War Flying Annual," F. T. Jayne. London, 1916, Sampson Lon, Marston & Co. (Illustration and dimensions of aircraft of different nations.)
"Curtiss Aviation Book," Glenn H. Curtiss and Augustus Post. N. Y., 1912, F. A. Stokes. (Biography and early experiences with Curtiss machines.)
"Elementary Aeronautics," A. P. Thurston. London, 1911, Whittaker & Co. (Contains interesting stream line photographs.)
"First Man-Carrying Aeroplane Capable of Sustained Free Flight—Langley's Success as a Pioneer in Aviation," A. F. Zahm. Washington, 1915, Smithsonian Institution. (Account of flights of reconstructed Langley "Aerodrome.")
"Flying: Some Practical Experiences," Gustave Hamel and C. C. Turner. London, 1914, Longmans Green & Co. (Popular treatise with photographs, many of them taken from flying machines.)
"Jahrbuch der Luftfahrt," A. Vorreiter. München, 1912 (Annual publication, J. F. Lehmann.) (An excellent general book.
"Jahrbuch der Wissenschaftlichen Gesellschaft für Fugtechnik." Berlin, 1913, 1914, 1915, J. Springer.
"Memoir on Mechanical Flight," S. P. Langley and C. M. Manely. Washington, 1911, Smithsonian Institution. (Construction and experiments with model and full sized self-propelled flying machines; sequel now being compiled.)
"My Airships," Santos Dumont. N. Y., 1904, Century Co. (Popular accounts of early experiments with dirigibles.)
"Progress in Flying Machines," Octave Chanute. N. Y., 1894. American Engr. & R. R. Journal. (Compendium of experiments to date, 1894, made throughout the world in mechanical flight.)
"Practical Aeronautics," C. B. Hayward. Chicago, 1912, Am. School of Correspondence. (Large volume containing much elementary information regarding theory and construction of aircraft.)
"Revue Générale de l'Aeronautique." Paris, Libraire Aéronautique (Vols. 1-4 published several years ago, each volume by a different author.)
"Romance of Aeronautics," C. C. Turner. London, 1912, Seeley Service & Co. (An interesting acount of the growth and achievements of all kind of air craft up to 1912.)
"Researches and Experiments in Aerial Navigation," S. P. Langley. Washington, 1908, Smithsonian Institution. (Accounts of successful experiments with the Langley model airplanes.)
"Taschenbuch der Luftflotten (Kriegsausgabe)," F. Rasch and W. Hormel. Munich, 1915, J. F. Lehmann. (Pictures of balloons, dirigibles, airplanes and engines.)
"La Technique Aéronautique," Tomes 1-6. Paris, 1912, Librairie Aéronautique. (These volumes were published twice a year; containing technical and general treatises. Nos. 5 and 6 bear date 1912.)

Comprehensive Courses of Study

"Cours D' Aérontique," L R A. E. Marchis, Faculté des Sciences de Paris. Paris, 1910, ut seq., Dunod et Pinat. (University of Paris course put into book form, containing much historical and technical information: Vol. I, 1910, Statics and Dynamics of Balloons: Resistance of the Air; Vol. II, 1911, Aerotatics, Design, Aviation, Eiffel's Early Aerodynamical Experiments; Vol. III, 1912, Dynamics of Fluids, Various Aerodynamical Laboratory Aparatus.)
"Cours D'Aviation," Georges Espitallier. 4 Vols. Paris, 1911. Ecole speciale des Travaux Publics.
"Fligerkurs Leitfaden für Militär und Zivilflieger," Joel Flassig. Vienna, 1913, J. Eberle & Co.

"Leçons sur la Navigation Aérienne," L. R. A. E. Marchis. Paris, 1904, Vve. C. Dunod. (Theory and operation of lighter-than-air-craft).
"Le Navire Aérien" (Architecture, Equilibre, Stabilité), L. R. A. E. Marchis. Leçons faites en 1908-9 à la Faculté des sciences de l'Université de Bordeaux. Paris, 1909, Dunod et Pinat. (Treats chiefly of Balloons.)

Meteorology

"Aeronautisches Observatorium in Lindenberg." Berlin, 1906, ut seq.
"The Atmosphere," F. J. B. Cordiero.
"The Conquest of the Air," J. L. Roth. N. Y., 1909, Moffat Yard & Co. (Contains a chapter on Aeronautics and Meteorology.)
"Charts of the Atmosphere for Aeronauts and Aviators," Rotch & Palmer. N. Y., 1911, J. Wiley & Sons.
"College Physiography," Tarr & Martin. (Contains chapters in which are a digest of Fundamental Principles of Meteorology.)
"Free Air Data: Sounding Balloon Ascensions at Indianapolis, Omaha and Huron," Wm. R. Blair. Washington, 1912. (Bulletin, Mt. Weather Observatory of Bluemont, Va.)
"The Internal Work of the Wind," S. P. Langley. Washington, 1893, Smithsonian Institution. (Sets forth Langley's theory of soaring flight.)
"Meteorology," Milham. (Text book of Meteorological Phenomena.)
"Mechanics of the Earth's Atmosphere," Cleveland Abbé. (First Volume 1891, second 1910, a collection of translations of various scientific papers on the earth's atmosphere.)

Bird Flight

"Aeroplane Designing for Amateurs," Victor Lougheed. Chicago, 1912, Reilly Britton Co. (Experiments to determine Bird Wing Shapes, page 56.)
"Animal Flight," Hankin. London, 1913, Iliffe & Sons. (Observations in India and Egypt.)
"Animal Locomotion, Walking, Swimming and Flying," J. B. Pettigrew. New York, 1874, D. Appleton & Co.
"Animal Mechanism—A Treatise on Terrestrial and Aerial Locomotion," E. J. Marey. New York, 1874, D. Appleton & Co. (Laboratory Analysis of Bird Wing Stroke; International Scientific Series Vol. II.)
"Aviation, Comment l'oiseau vole, comment l'homme volera," Wm. Kress. (1905, Translated into French from German 1909.)
"Bird Flight as the Basis of Aviation," Otto Lilienthal. Berlin, 1889. English translation, N. Y., 1911, Longmans, Green & Co. (Results of numerous experiments made by O. and G. Lilienthal.)
"Comment volent les Oiseaux—Le Vol Ramé," R. Desmons. Paris, 1910, Dunod et Pinat.
"Die Flugberwegung der Vögel," Karl Milla. Leipsig, Vienna, 1895, F. Deuticke.
"L'Empire de L'Air," L. P. Mouillard. Paris, 1881, G. Masson. (Pioneer study of soaring birds and gliders. An English translation, "The Empire of the Air," was published 1893 by U. S. Govt. Printing Office.)
"Essay on the Theory of the Flight of Birds, Bats and Insects," C. J. L. Krarup-Hansen. Copenhagen, 1869, C. Steen & Fils. (Popular treatise.)
"Flight of Birds," G. A. Borelli. London, 1911. Aeronautical Soc. of Great Britain. (Republication of Borelli's work as one of the "Aeronautical Classics.")
"Flight of Birds," F. W. Headley. London, 1912.
"First Report of the Bird Construction Committee," J. D. Fullerton, London.
"The Greatest Flying Creature," S. P. Langley and E. A. Lucas. Washington. Published by the Smithonian Institution.
"Les Organes de locomotion aérienne chez les vertébrés volants," R. Anthony. Paris, 1913, Librairie Aeronautique.
"Physiologie due Mouvement, Le voll des Oiseaux," E. J. Marey. Paris, 1890, G. Masson.
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Second Report of the National Advisory Committee for Aeronautics

This report, comprising five technical papers and an introduction, makes up a volume of six hundred and fifty pages. The introduction includes an explanation of the methods by which the committee does its work, and a brief resume of the problems now under investigation. These latter cover a wide range, including laboratory tests of various sorts, the further mathematical investigation of stability, researches on metals, the preparation of an up-to-date aeronautical bibliography to supplement Brockett's work in this field, etc. A financial report for the past year, and an estimate of the needs of the committee in carrying out its plans for the future, are also included.

The first two of the five technical reports, those on aeronautic instruments and nomenclature, have already been reprinted in AVIATION AND AERONAUTICAL ENGINEERING, and call for no comment now. The third, presented by Profs. H. Diederichs and G. B. Upton, of Cornell University, is devoted to mufflers for airplane engines, and gives a summary of what has been so far accomplished along these lines, in addition to the results of some experiments performed at Cornell.

The fourth report, and by far the most important of all, is by Prof. Charles E. Lucke of Columbia University, assisted by Prof. F. O. Willhofft, and deals with the design of gasoline carbureters. It consumes, in itself, more than five hundred pages. The first part of the report gives a general review of the problem to be solved. The second is made up of a complete list and classification of all United States patents relating to carbureters. This is followed by a reclassification of these patents according to a new system, and by drawings and specifications pointing out the salient features of some hundreds of devices from among the several thousand examined. Part five is devoted to the theory of carburetion, and includes theoretical and empirical formulas for the flow of fluids. Part six gives the results of a large number of tests on standard American carbureters, and is illustrated by a large number of curves. The report closes with a discussion of the literature on the subject, and a brief tabulation of conclusions and recommendations for future researches.

The last report is a translation of a paper by L. Marchis, Professor at the University of Paris, on "Experimental Researches on the Resistance of Air." The various types of aeronautical laboratories are discussed, and those at present in operation in France are described. There is a thorough treatment of graphical methods, including analyses of the so-called logarithmic charts used by M. Eiffel and others, and of the notations whereby the results of model tests of all sorts can be applied to full-scale practise. This is followed by an inquiry into the extent to which such applications are permissible. There are also summaries of a great number of tests on flat plates, wings, and propellers.

The report is a worthy successor to last year's, and helps the reader to some idea of the value to the aeronautical world of such scientific organizations as the National Advisory Committee and the British Advisory Committee. The work of the laboratory is not spectacular, but it is no less essential than that of the designer or pilot or manufacturer of machines.

Aircraft Industry Needs Standardization

By Howard E. Coffin

of the Council of National Defence

The rapid growth of the American motor car industry has been looked upon as one of the wonders of the world's progress, but the developments in machines for the navigation of the air bid fair to eclipse even the spectacular rise of the horseless road vehicle. Perhaps never before have men in the same decade been privileged to live through and take part in two great movements which so vitally affect the course of human affairs.

Long before history began man's endeavor was centered upon the solution of the problem of transportation. The animal-drawn cart, the chariot, the coach, the steam and the electric railway record the progress of the centuries. With the commercial advent of the automobile only a few years ago the last word in the refinement of a method of individual transportation seemed to have been reached.

But now almost before we have become accustomed to the economic changes wrought in our daily round of life by this horseless road vehicle we are forced again to revise our whole line of thought. We have been wont to picture ourselves as creatures moving about on top of the earth. We are now asked to conceive that we are living at the bottom of an ocean of air, that we are crabs, jellyfish, snails, oysters or human whatnots by classification of temperamental endowment or cultivation. We must believe that for miles above us and about us there is a weighty medium through which and on which we must learn to move from place to place.

No other means of transportation has come upon us with the suddenness of the flying machine. The European war has set the clock of this art ten years in advance. The end of this development cannot even be guessed.

Less than one year ago the American aircraft industry did not exist. Here and there inventors were following up hobbies of their own. In only two or three instances were commercial outputs achieved or even seriously considered. Governmental support was almost entirely lacking, and the only obligations felt by the inventor-builder were those of a financial kind.

Millions Have Been Appropriated

But suddenly all of this has been changed. Milions of dollars have been voted for aircraft by Congress, and the industry thus suddenly born has become a vital necessity in our plan for any future defence of this nation. The individual engineer or builder is no longer an irresponsible free lance, but has become merely a cog in the great industrial machine in which the American nation is vitally interested. No human enterprise can expand twenty fold in a few months and continue a normal, healthy and logical growth.

As a result of our rapid expansion in aeronautics, chaotic conditions are sure to ensue. Governmental departments organized to handle a million dollar business annually are now expected to increase their activities by fifteen or even twenty fold and with a personnel forcedly inadequate through Congressional or legislative limitation. No standards in specification and test of materials, in design of even minor parts, or in method of production and treatment exist for the guidance of the aeronautic engineer.

The engineer is the originating end in any industry, and if his work is faulty or lacking in its adherence to accepted standards of excellence the efforts of all the other departments of the plant cannot make good his error. Some of us who are now watching developments in this great new industry have spent many years of our lives in solving the problems and smoothing out the engineering and production difficulties in the motor car field.

The vast quantity production of motor vehicles in this country—many times that of all the other countries of the world—has been made possible only through the close cooperation of automobile engineers in the creation and use of standards in every phase of the art. Steel or cotter pins, tires or bolts, shaft ends or fittings—everywhere the quantity supply of materials and parts is safeguarded against the inexperienced or irresponsible draughtsman through accepted and widely published standards, both as to materials and design.

Standard materials may be stocked in quantity at their source and shipped immediately upon receipt of order. One instance only need be given to show the present state of affairs in the aircraft field and to emphasize the necessity of instant action.

Chaos in Parts Manufacture

A certain manufacturer of screw machine parts is operating a large plant almost exclusively on airplane fittings for many different concerns. In one particular bolt used for the same purpose by these airplane builders he is asked to turn out of his plant simultaneously six different specifications as to metal, each requiring a special heat treatment, fifty different lengths, eight variations of a few thousandths of an inch each in diameter, and six different thicknesses of bolt head, amounting in all to several thousand variables intended to serve almost exactly the same purpose.

When the further statement is made that this same maker is supplying more than three thousand parts for one well known model of airplane, these parts divided into 240 separate items, one may begin in some manner to appreciate some of the reasons for slowness in delivery on Government contracts for aircraft for the defensive service of the nation. The seriousness of this situation can be guessed when it is realized how utterly impossible is quantity delivery of finished machines in the absence of even such simple standards.

The aircraft art is young, and large investments in dies, jigs, special tools and production tools and fittings have not yet been made. No time must be lost in beginning this work on standards, upon which must be based the whole future development of the industry. In the automobile business this work had to be done after millions of dollars of manufactured products were in the hands of private owners and after other millions had been invested in producing machinery. Hundreds of thousands of dollars worth of tire moulds and appliances had to be scrapped by the tire makers alone when standards were adopted in tire and rim sizes.

Standardization Coming

Standardization in the motor car industry was forced because materials could no longer be purchased under the multiplicity of special requirements drawn to suit the unrestrained whim of the designer. Like action will soon be forced in the aeronautical field—in fact, is being forced there now—and unless we can have definite accomplishment here and without delay, we will have before us the spectacle of the throttling of our plans for national defence.

The production of aircraft in America today is limited to the ability of parts makers to make delivery on non-standard materials. Will we profit by the lessons of the motor car industry and cure this ailment while the art is yet young?

Diseases of Airmen

(From the Lancet.)

From leakage of petrol spray the pilot may become dizzy, and the exhaust gases from the engine—carbon monoxide and dioxide—may cause headache, drowsiness and malaise. The rarefied air at great elevations may induce the symptoms well known in balloonists, and Wells refers to a case of frost-bite in an airman who had been exposed to 34 degrees of frost at an elevation of 15,000 feet. Psychasthenic symptoms—namely, loss of self-confidence and the resulting mental worry (aerosthenia)—are not uncommon, and prove that the victim has mistaken his sphere of activity.

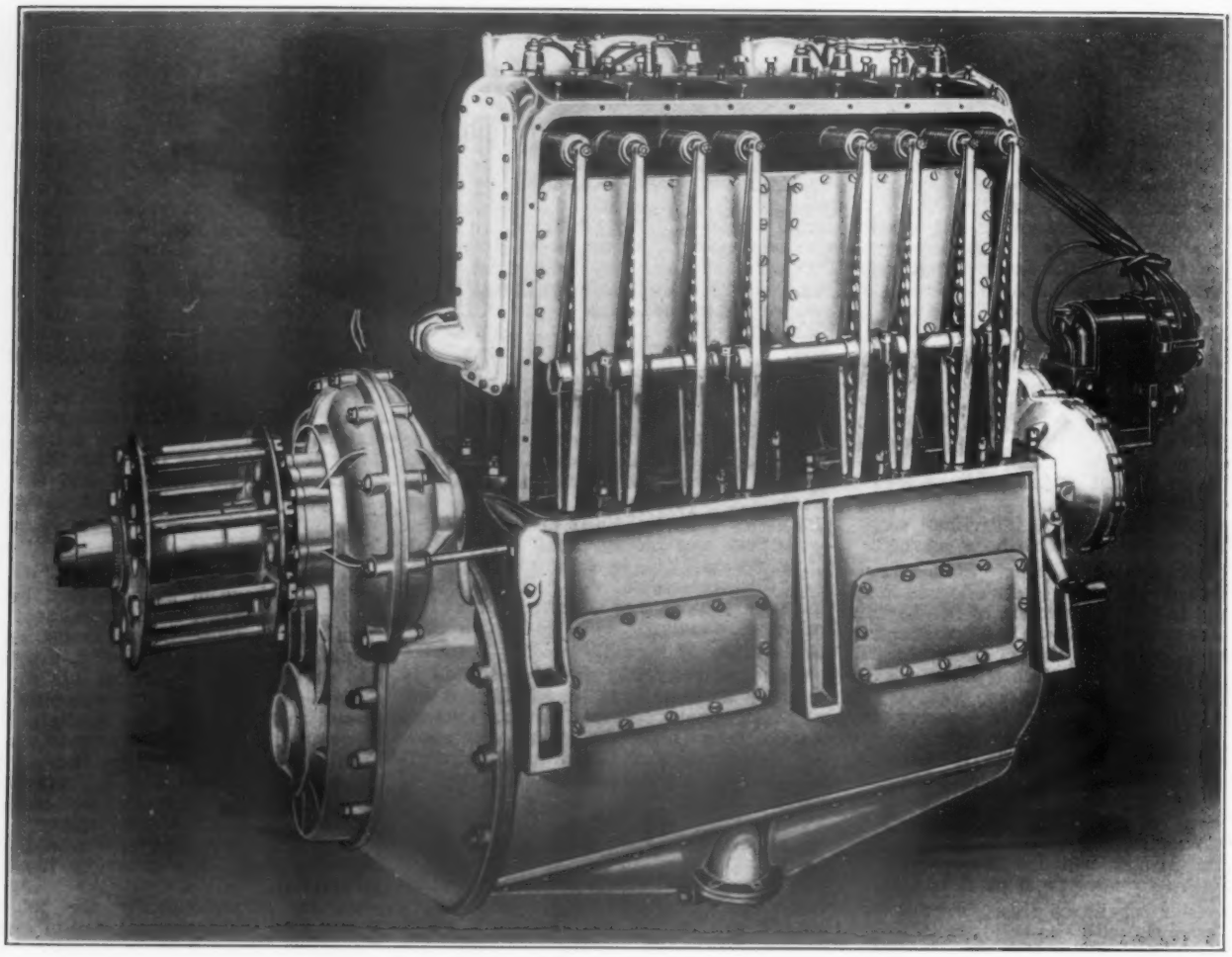
Flying is undoubtedly the job of a young man under thirty years of age, and not every young man is temperamentally or physically fitted to carry it through. Perfect eyesight is necessary to insure safe landing, correction with glasses being not without its dangers; perfect hearing is essential to detect the first indications of engine defect, and free movement of the joints of the lower limbs to control the steering gear. Fits and tendency to faint absolutely deter the aspirant from the air service. In one remarkable instance at Haslar an airman who fainted with the result that the airplane dived nose downward 1,200 feet into a ploughed field, escaped with such minor injuries that he was at first extremely loath to give up this branch of the service.

Government Wants Aircraft Inspectors

The United States Civil Service Commission is conducting examinations to fill the position of assistant inspector of engineering material for aircraft. There are at present six positions open, paying from $4.48 to $5.04 per day, and the commission, due to the lack of eligibles and urgent needs of the service, is receiving applications at any time, rating examination papers when received, and will make appointment with the least possible delay.

Competitors must have had at least one year's experience as machinist in a factory constructing gas engines for automobile or airplane use, or as inspector of airplane or automobile engines, or one year's actual experience in flying. In the examination, experience counts for sixty points, and education of a technical nature for forty points out of a total of 100. Applicants are to apply for Form 1,312 to the Civil Service Commission, Washington, D. C., stating the title of the examination.

The Duesenberg 4-Cylinder 16-Valve Engine



The Duesenberg Motors Corp., which has produced highly successful automobile and motor boat engines, is now making at its new plant at Edgewater, N. J., airplane engines, and is in a position to fill orders.

The photograph shows the four-cylinder engine, brief specifications of which are: bore 4¾ in., stroke 7 in., weight, with magneto, carburetor, gear reduction and propeller hub, 509 lb.; without gear reduction 436 lb. The manufacturer states that the engine develops 125 hp. at 2100 r.p.m. (propeller speed 1210 r.p.m.)

There are two inlet and two exhaust valves for each cylinder. The cylinders are semi-steel, with aluminum plates enclosing water jackets. Pistons are Magnalite aluminum compound and specially ribbed. Valves are tungsten steel, 1 15-16 in. inlet and 2 in. exhausts. The valve stems are lubricated by splash in the valve action covers. Connecting rods are tubular, chrome nickel steel. The crankshaft is one piece forging, hollow bored, 2½ in. in diameter at main bearings. The crankcase is of aluminum, barrel type.

The engine is lubricated by an oil pump in the base, supplemented by a splash system. An oil pressure of approximately 25 lb. is maintained, thus insuring thorough lubrication. The troughs under the connecting rods are constructed so that each rod will dip up a supply of oil, regardless of the angle of flight.

The engine can be operated with or without the reduction gear. Two of these engines can be installed side by side in a comparatively small space, which is an advantage in some cases.

Manufacturers' Association Activities

The Aircraft Manufacturers' Association has opened executive offices at 501 Fifth avenue, New York City, and is now taking measures to obtain definite information on the resources of manufacturers and the producers of raw material in connection with materials entering into the construction of aircraft of all descriptions.

Manufacturers of small parts, fittings, etc., and mills producing fabrics suitable for wing covering are invited to submit samples and catalogs, together with a statement of their ability to produce the various products, which is to be placed on file with the Association.

One of the objects of the Association is to create a clearing house for the exchange of ideas and to obtain and standardize small parts and equipment and in this work it is cooperating with the National Advisory Committee for Aeronautics.

S. A. E. Summer Meeting

Because of war conditions, the summer meeting of the Society of Automotive Engineers, scheduled to be held the last week in June at Ottawa Beach, Lake Michigan, was called off by the Council of the Society at a meeting held a few days ago in Chicago. The engineers are more and more engrossed in war activities, and few of the members have the spare time for such a meeting.

Instead of four days at Ottawa Beach it was voted to spend one day on the summer meeting and hold it in Washington, D. C., on Monday, June 25. Washington was selected because many Government departments are closely associated with the work of the Society.

S. A. E. Opens Washington Office

A Washington office of the Society of Automotive Engineers will be opened in the Munsey Building in connection with the Council of National Defense as soon as arrangements can be made. Coker F. Clarkson, general manager, or his assistant, Herbert Chase, will probably represent the society almost continuously in the Washington office.

It is possible the Society will assist in aviation standardization work, and also in the training of mechanics for aviators as well as in training and supplying mechanics for many other parts of war service.

Joy Aviation Field Offered to U. S.

Joy field, near Detroit, owned by Henry B. Joy, has been offered through Sidney D. Waldon to the United States Government for aviation training. This field was inspected in 1915 by United States aviation officers and a favorable report was made. The Packard Company has been testing its aircraft motors out on this field, which is near Mount Clemens.

Philosophical Society Discusses Aeronautics

Discussion of aeronautics marked the closing at Philadelphia of one of the most interesting and important conferences ever held by the American Philosophical Society.

Among the subjects considered was the selection and application of a fuel that would cost less than gasoline and at the same time contain desired qualities in giving power for an airplane engine.

Safe Route for Aviators

The establishing of regular "safe routes" from place to place was explained by Charles F. Marvin, Chief of the United States Weather Bureau. He stated that through the use of balloons, temperatures and wind currents between certain towns, or army posts could be easily recorded and from data collected in this way, routes could easily be layed out. So complete would information, gathered in this way be that a time schedule could also be arranged.

Mechanical Aspects of Airplanes

William Frederick Durand, Ph.D., chairman of National Advisory Committee for Aeronautics, read a paper on the mechanical aspects of the airplane. Dr. Durand said that "the high price of gasoline, which is used as fuel in all American airplanes, forms a barrier hard to get over. Due to this fact a serious limitation is placed upon the economic use of the airplane for either military or commercial purposes. The development of an engine which will use fuel other than gasoline is one upon which many are now concentrating their minds.

"It will not be without interest at this point to note the fuel cost per ton-mile for airplane services as compared with the same item for railroad and marine transport," said Dr. Durand. "If we take an airplane with, say, 130-hp., carrying nine hundred pounds of cargo at a speed of sixty miles per hour, with gasoline as fuel, which now costs in quantities 20 cents per gallon, we will find that the cost is high, being about 10 cents per ton mile.

"This will compare with about 1-10th cent in the case of a heavy freight train and with about 1-40th cent in the case of a 10,000-ton steamer. The fuel cost for merely carrying dead weight may, therefore, readily be from one hundred to four hundred times as great as for railroad or marine carriage.

"Therefore, for the ship the net cargo weight may be, for moderate speeds as high as 50 per cent of the gross weight, while for the airplane it will be from five to eight times this amount.

"Again, the ship requires for, say, a speed of 15 miles per hour, a horsepower of 5,000 or less, or not exceeding 1 hp. for 4,500 lb. gross weight. On the other hand, the airplane requires something like 1 hp. for 15 to 20 lb. gross weight. Again, the fuel for the airplane engine costs eight times as much per horsepower hour developed as for the ship prime mover."

Effect of Air Currents

Dr. Edwin Bidwell Wilson, Ph.D., professor of mathematics of the Massachusetts Institute of Technology, read a paper on air currents with regard to aeronautics. Most air currents, according to Prof. Wilson, are not dangerous. He explained that a current of air catching the plane from below would do no more than simply raise the plane about 70 ft. higher and that no mishap would be likely to result. Side gusts and rotary gusts are the ones which most try the mettle of the aviator. The rotary gust is the most dangerous of these, especially when encountered in a head-one direction. Should the aviator be unfortunate enough to come in contact with a rotary current the plane would be whirled around and finally sent in a spiral dive to earth and destruction. The side currents catching the rear of the airplane forces the front of the plane around, bringing the craft head on into the current. Rotary currents of air are generally encountered when flying near a building or over a forest. These are caused by the earth's attracting air currents. For this reason aviators always climb to an altitude of several thousand feet when making a flight.

Favored Standard Sizes

Dr. Jerome C. Hunsaker, assistant naval constructor of the United Stated Navy, spoke on the problems encountered by the Navy Department in the construction of all types of air craft. He was highly in favor of building all airplanes a standard size, but stated that at present this could not be done, due to the many types of machines.

Regarding currents in the air, he stated that in a recent accident a Government plane, which was flying near a battleship, suddenly turned and crashed into the bow of the ship. Although this machine was being piloted by one of the Army's most competent men, no definite solution of the accident was ever made. He said he believed that this machine was caught in a rotary current, as had been explained by Dr. Durrand.

Du Pont Aviation School

An aerial patrolling system, involving the expenditure of $500,000 for equipment and an annual upkeep cost of $250,000, has been announced by Pierre du Pont of Wilmington, Del., for the protection of the E. I. du Pont de Nemours & Co.'s plants, according to the *Investment Bulletin*. It is to be in operation within thirty days.

The station will be in charge of Harry N. Atwood, head of the Atwood Aeronautic Company of Williamsport, Pa. Orders were placed last week with the Curtiss Aeroplane Co. of Buffalo for $100,000 worth of machines, and the Thomas-Morse Aircraft Corp. also received an order for $50,000 worth of equipment.

In addition to protecting the powder works from aerial attacks the Du Pont system will serve as a training school.

Princeton Aviation Corps Formed

Through the patriotic generosity of Percy Rivington Pyne, '78, the Aviation Corps of Princeton University has been presented with two Curtiss JN-4 airplanes, which will enable the prompt formation of the corps for training. Mr. Pyne has also agreed to pay for the hangars for the machines, and for the expense of the necessary mechanicians to maintain the airplanes.

Over 200 Princeton students have applied for service in the flying corps, and of this number sixty will be chosen for training. A flying field has been secured and active work will be started as soon as the two machines arrive, which is expected to be during the first week in May.

Lieutenant Edward R. Kenneson, of the Army Reserve Flying Corps, will be head instructor, and Marshall F. Mills, '02, has been made General Director of the Corps, which has the following list of officers:

President: ex-officio, John Grier Hibben, president of the University.

Faculty Board: Professors Trowbridge, Raycroft, Thompson, Brown, Heermance, Mather and Kemmerer, Col. Libbey and Captain Silvester.

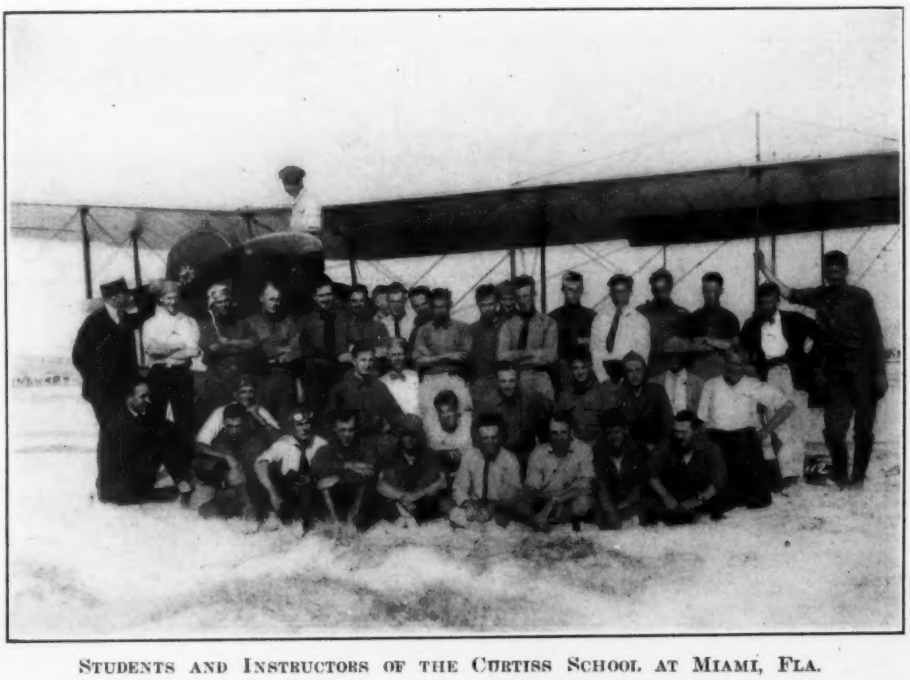
Undergraduate Officers: president, D. E. Bardwell; vice-president, V. C. Grant; secretary, W. B. Kelly.

Advisory Board: Capt. Heintzelman, Percy R. Pyne, Rodman Wanamaker, James Barnes, Marshall Mills, Hobart Baker, H. H. Salmon, Jr., Prof. K. N. Condit and Prof. F. H. Constant.

Benoist Building Large Seaplane

The Benoist Aeroplane Company have finished three of their standard 100-hp., three-passenger boats, which they are now using in the school at Sandusky, Ohio, and are working on a large twelve-passenger boat to be equipped with a 350-hp. 12-cylinder Roberts engine. This large machine is to be used in the passenger-carrying service between Sandusky and Put-in-bay. It is contemplated to make a round trip each day during the summer between these two points, and one or two round trips a week between Sandusky and Detroit.

Besides these large machines, specifications are going through for a twenty-five-passenger twin-motored Benoist cruiser to use two of the 350-hp. Roberts engines. This machine will probably be one of the largest built, and will differ from the usual twin-engined machine, in that both engines are placed in the bow of the boat.



STUDENTS AND INSTRUCTORS OF THE CURTISS SCHOOL AT MIAMI, FLA.

Dayton Wright Airplane Co. Organized

Announcement is made of the formation of the Dayton Wright Airplane Co., with $500,000 capital, and the Wright Field Co., with a capital of $10,000, both with offices at Dayton, Ohio.

The directors are Orville Wright, Edward A. Deeds, president of the Dayton Engineering Laboratories Company; Charles F. Kettering, Harry E. Talbott and Harry E. Talbott, Jr., the last named being president.

The airplane company will manufacture airplanes, and the field company will conduct an aviation school, which is expected to work in cooperation with the United States Army, in training military aviators.

The school will be operated under the direct supervision of Mr. Wright, with Howard M. Rinehart as chief instructor. The formal opening will take place between May 15th and June 1st.

Machines are already under construction and are being equipped with Hall-Scott engines. It is expected that the first of the new machines will take the air within two weeks.

New Naval Aviation School

Lieut. Robert W. Emmons, 2d, chairman of the subcommittee on naval forces of the Massachusetts Committee on Public Safety, has requested that notice be given that the Naval aviation school at Squantum, which was announced to open on June 1, will now open on May 1 or soon after.

This change in the opening date for classes at the new aviation school is possible because of the progress made in preparing the grounds and in the work on the hangars, etc.

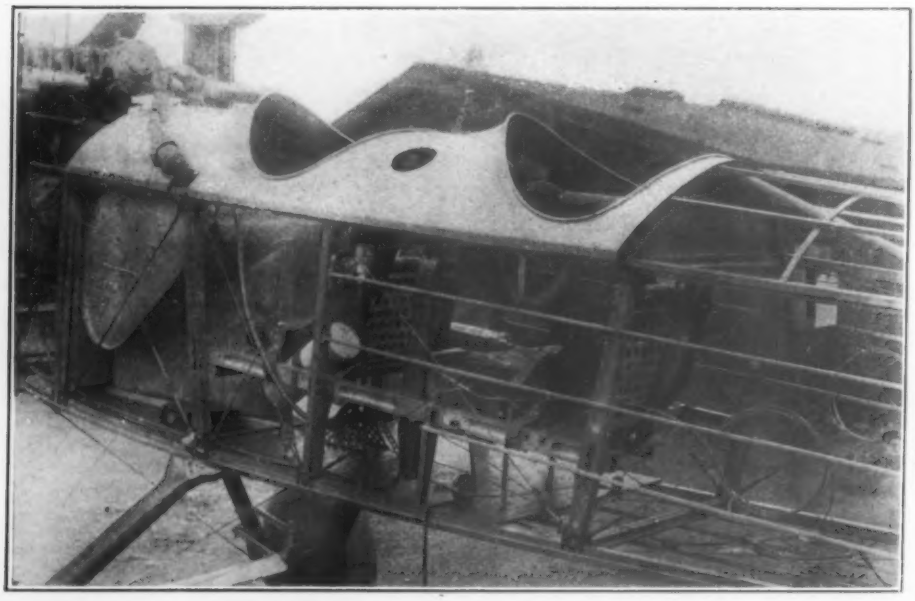
Because of this advancement of the opening date, it is possible to train one more class of men than had been expected, and, therefore, the Committee on Naval Forces requests that all men intending to apply for admission in these classes, appear personally at the rooms of this committee at the State House, where all information and blanks are obtainable.

To join the flying squadron classes, applicants must be between 18 and 24 years old, must have a college education or be a college student, or at least have extra mathematical training; must be of sound physical health, and have perfect sight and hearing.

MAJOR L. W. B. REES, OF THE ROYAL FLYING CORPS, NOW HERE WITH THE BRITISH MISSION

Maj. Hersey Goes to Fort Omaha

Major H. B. Hersey, who formerly was at the head of the Milwaukee weather bureau, has been given an appointment in the lighter-than-air division of the air staff of the United States army and will proceed to Fort Omaha for duty.



SEATING SECTION OF THE STANDARD MODEL H-3

Columbia Students Form Unit

One hundred and twenty-five students and alumni of Columbia University, New York City, have enrolled in a flying corps, approved by the National Aerial Coast Patrol Commission, and to be known as Aerial Coast Patrol, Unit No. 4. The unit has been given the use of a seaplane belonging to Howard S. Borden, and will begin training on Long Island within a few days. Instruction will be given by Philip Sims, who has seen service as an aviator in the English army.

First Naval District Station

A naval aviation training station and base has been opened at Marblehead, Mass., by the naval reserve. Twelve officers and 100 men will man the station, which will be in command of Lieut. Godfrey L. Cabot, aide to Lieut. Edward G. Blakeslee. The camp will be the first to be established by the Government in the first naval district.

Richardson Building Factory

The Richardson Aeroplane Corp. of New Orleans has begun the construction of a factory on the shore of Lake Pontchartrain.

It is stated that test flights of the biplane to be made will be possible within sixty days.

Army School at Chicago

The War Department has practically completed arrangements for opening a training school for pilots at the field of the Illinois Aero Club at Ashburn, near Chicago.

The site was selected by Col. Samuel A. Reber and Capt. Joseph C. Morrow, of the Signal Corps. Capt. Roy S. Brown will be the officer in charge.

Seventy-five students, to be chosen from the hundreds of applications, will undergo training. The station will start with an equipment of forty-eight Curtiss machines.

St. Louis Wants Army School

Contributions are being received for a campaign inaugurated by the Missouri Aeronautical Society and other organizations interested in aviation for the purpose of raising a fund to lease grounds in the St. Louis district which are to be placed at the disposal of the United States army for an aviation field.

John G. Lonsdale, treasurer of the society, is receiving contributions, which range from $5 to $1,000. The men interested in bringing one of the aviation stations to St. Louis are anxious to collect sufficient money by the end of next week to wire the department an offer of a site.

Gnome Engine Construction

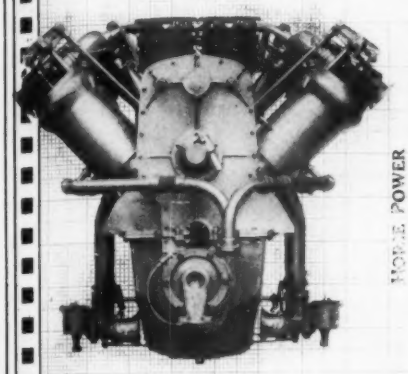
In the construction of the 100 hp. Monoplane Gnome airplane engine, 55 forgings are used for each engine, having a total weight, before being machined, of 1900 lb. The total weight of the engine complete being only 272 lb., the great difference between the weight of the rough forgings and the finished parts strikingly illustrates the work necessary to make an engine of this kind.

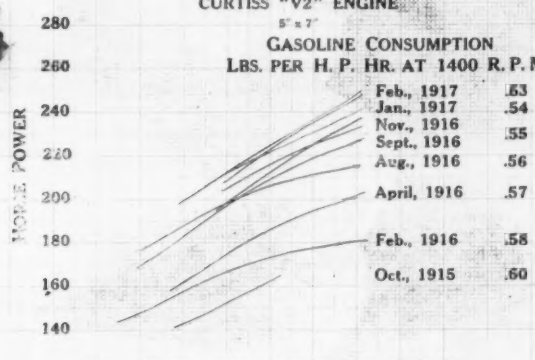
New Curtiss School at Buffalo

The new aviation school of the Curtiss Co. on Lake Erie, is rapidly approaching completion, and will be opened at an early date.

CURTISS AEROPLANE & MOTOR CORPORATION

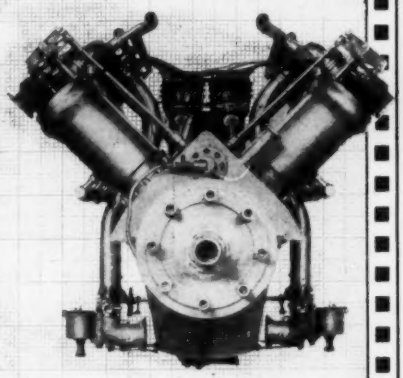
BRAKE HORSE POWER CURVES
SHOWING THE PROGRESSIVE PERFORMANCE
OF THE
CURTISS "V2" ENGINE
5" x 7"

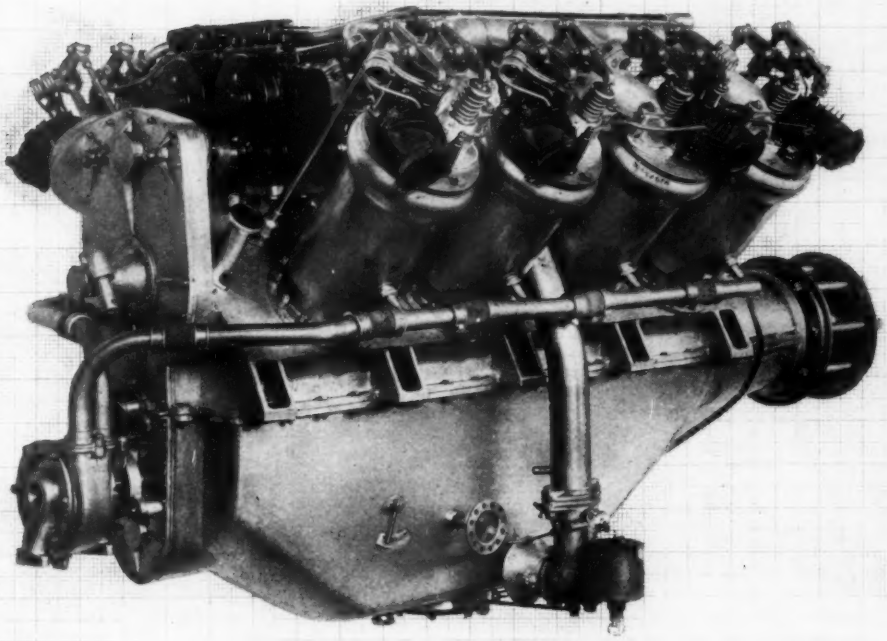




GASOLINE CONSUMPTION
LBS. PER H. P. HR. AT 1400 R. P. M.

Feb., 1917	.53
Jan., 1917	.54
Nov., 1916	.55
Sept., 1916	
Aug., 1916	.56
April, 1916	.57
Feb., 1916	.58
Oct., 1915	.60





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Oiling-force feed to all bearings.

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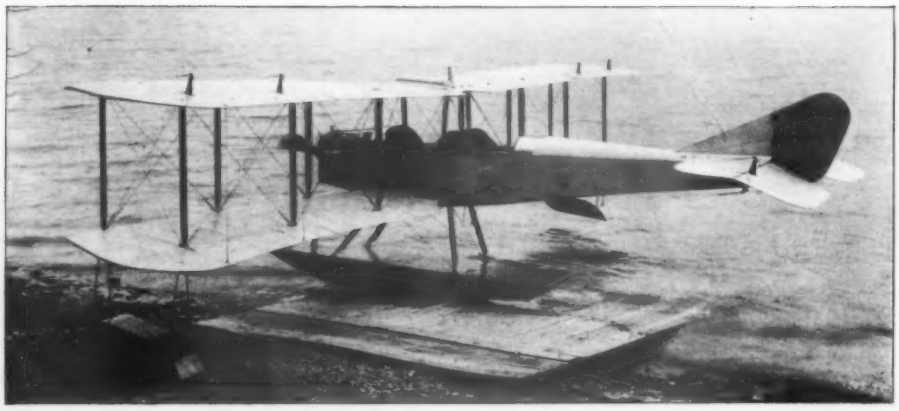

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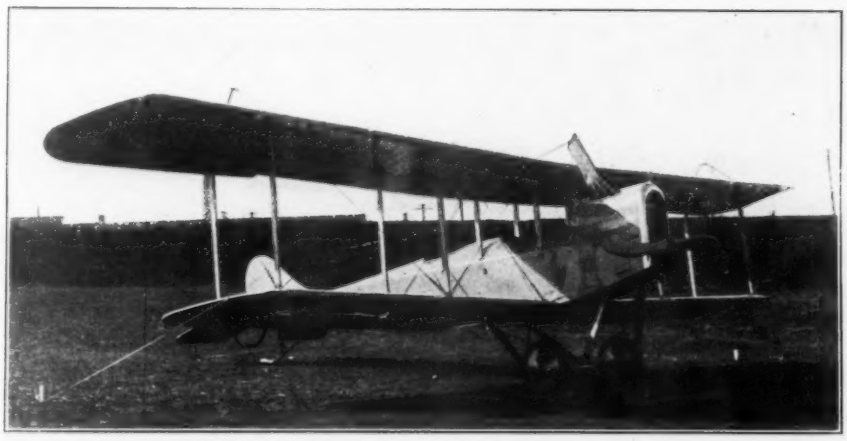

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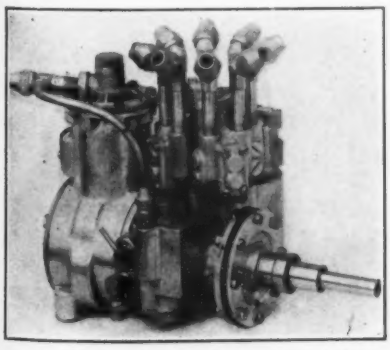

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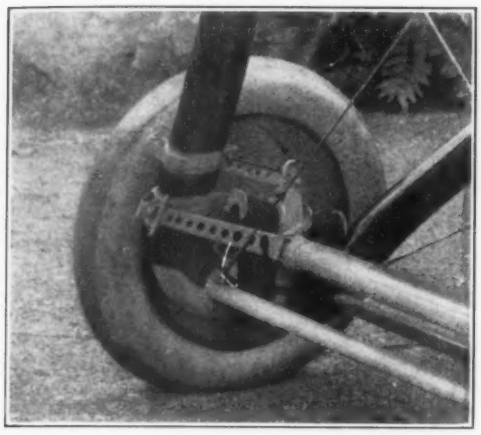

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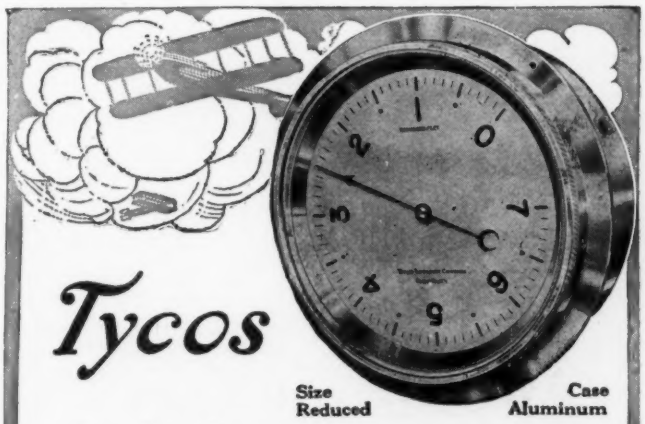

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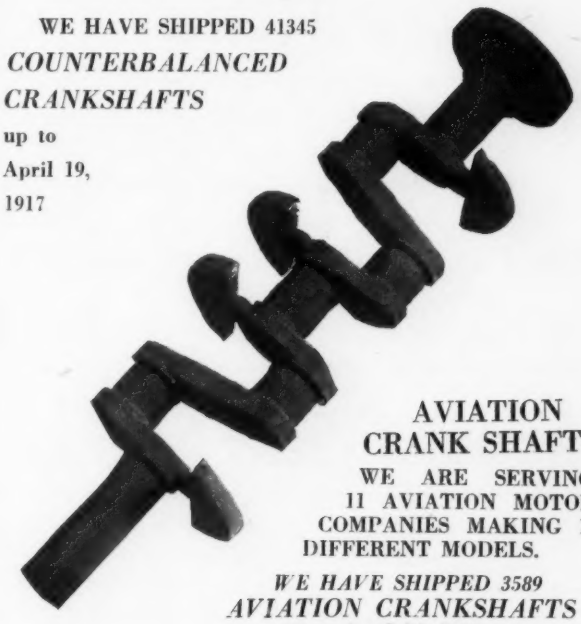

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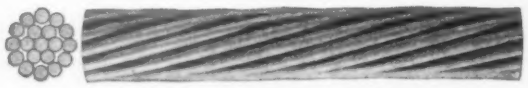

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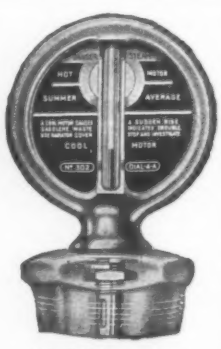

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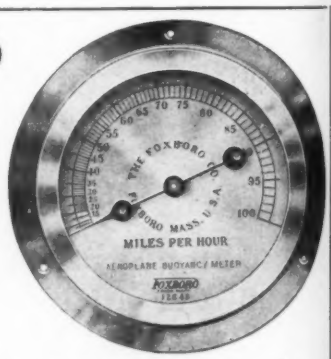

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Christofferson Motor Corp.
Curtiss Aeroplane and Motor Corp.
Duesenberg, Fred S., Motor Co.
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
Hall-Scott Motor Car Co.
Harriman Aircraft Motors Co., Inc.
Knox Motors Co.
Maximotor Co.
Miller, Harry A., Mfg. Co.
New Jersey Aeroplane Co.
Orio Motor Co.
Packard Motor Co.
Roberts Motor Mfg. Co.
Sterling Engine Co.
Sturtevant, B. F., Co.
Taft Pierce Mfg. Co
Thomas-Morse Aircraft Corp.
Union Gas Engine Co.
Wisconsin Motor Mfg. Co.
World's Motor Co.
Wright-Martin Aircraft Corp.

AIRPLANE PARTS
Chicago Aeronautical Supply Co.
Erie Specialty Co.

ALUMINUM
Aluminum Castings Co.
Aluminum Co. of America
American Metal Co., Ltd.
So-Luminum Mfg. & Eng. Co. (Solder)

AVIATION SCHOOLS
America Trans Oceanic Co., The
Beam School of Aviation
Christofferson Aviation School
Curtiss Training Schools
Davenport Aviation School
Dodge School of Aviation
Hall Flying School
Stinson School of Aviation
Thomas-Morse Aircraft Corp.
Williams Aviation School

BALL BEARINGS
Hess-Bright Mfg. Co.
New Departure Mfg. Co.
Norma Company of America.
S. K. F. Ball Bearings

BALLOONS AND DIRIGIBLES
Connecticut Aircraft Co.
Custer Specialty Co. (Statoscope)
French-American Balloon Co.
Goodyear Tire and Rubber Co.
Janney-Steinmetz and Co. (Hydrogen Cylinders)
United States Rubber Co.

BAROGRAPHS AND BAROMETERS
Green, Henry J.
Haustetter, A.
Sussfield & Lorch
Taylor Instrument Companies

BATTERIES
Electric Storage Battery Co.

BEARING METALS
American Bronze Co.
Fahrig Metal Co.
Magnolia Metal Co.

CARBURETORS
Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler and Schebler
Zenith Carburetor Co.

CLOCKS AND WATCHES
Ingersoll, Robt. H., and Bro.
Chelsea Clock Co.
Depollier, J., & Son
Waltham Watch Co.

CLOTHING
Abercrombie & Fitch
Cross, Mark
Meyrowitz, E. B. (goggles)
N. Y. Sporting Goods Co.
Rogers, Peet & Co.
Sanders Co.
Spaulding, A. G., & Bros.

COMPASSES
Sperry Gyroscope Co.
Taylor Instrument Companies

DOPE AND VARNISH
Adams & Elting Co.
American Emaillite Co.
Chemical Products Co.
Conover, The C. E., Co.
DuPont Chemical Works
Flexible Compound Co.
National Aeroplane Co.
Pratt & Lambert
Standard Varnish Works
Valentine & Co.

DRIFT INDICATOR
Sperry Gyroscope Co.

DYNAMOMETER
Sprague Electric Works

ENGINE PARTS
Allegheny Forging Co.
Burd High Compression Ring Co.
Doehler Die Casting Co.
Erie Specialty Co.
Fibre Finishing Co.
Gifford, Leland Co.
Gill, P. H., & Sons
Hydraulic Pressed Steel Co.
Levett, Walker M., Co.
Park Drop Forge Co.
Standard Parts Co.
Taft-Pierce Mfg. Co.
Tioga Steel & Iron Co.
Williams, J. H., & Co.
Wyman-Gordon Co.

EXHIBITION COMPANIES
The Cessna Exhibition Co.
Granburg, Gustav
Miller Aeroplane Co.
Weeks-Smalley Co.

FABRICS
Courtral Mfg. Co.
Lamb, Finlay & Co.
McBratney, Robt. & Co.
Scott, Hutchison Co.
Whitman, Clarence & Co.

FIRE EXTINGUISHERS
Fyr-Fyter Co., The
Johns-Manville Co., H. W.
Pyrene Mfg. Co.

GASKETS
Fibre Finishing Co.

GLUE
Ferdinand, L. W., & Co.
Baeder & Adamson.

GAGES
Crosby Steam Gage & Valve Co.
Foxboro Co., The, Inc.
United States Gage Co.

HANGARS
American Bridge Co.
Anchor Corrugating Constr. Co.
Ashley Steel Bldg. Co.
Howell, Field & Goddard, Inc.
Keasby & Mattison
Milliken Bros.

LIFE PRESERVERS
Universal Safety Mattress Co.

LUMINOUS COMPOUND
Cold Light Mfg. Co.
Radium Dial Co.
Radium Luminous Material Corp.

MAGNETOS
Bosch Magneto Co.
Berkshire Magneto Corp.
Ericsson Mfg. Co.
Remy Electric Co.
Splitdorf Electrical Co.

METALS
American Vanadium Co.
Acieral Co. of America (Aluminum Steel)
Bethlehem Steel Co.
Detroit Pressed Steel Co.
Federal Pressed Steel Co.
Garland Ventilator Co.
Gueder, Paeschke & Frey Co.

MODEL AIRPLANES
Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES
Excelsior Motor Mfg. Supply Co.
Harley-Davison Co.
Hendee Mfg. Co.
Militare Motor Vehicle Co. of America

OILS AND LUBRICANTS
Baker Castor Oil Co.
Graphite Lubricant Co.
Gulf Refining Co.
Sheppard Ideal Oil Co.
Standard Oil Co.
Texas Co.
Vacuum Oil Co.

OIL PUMPS
Wayne Oil Tank & Pump Co.

ORDNANCE
Buck Air Craft and Munitions Co.
Colt Firearms Co.
Driggs-Seabury Ordnance Corp.
General Ordnance Co.
Maxim Silencer Co.
Savage Arms Co.

PACKING
Fibre Finishing Co.

PHOTOGRAPHY
Brock, Arthur, Jr.
Herbert & Huesgen Co.

PONTOONS
Niagara Boat Co.
Welen Marine Equipment Co.

PROPELLERS
American Propeller & Mfg. Co.
Aviauto Mfg. Co.
Buffalo Aeroplane Corp.
C. M. O. Physical Laboratory
Excelsior Propeller Co.
Washington Aeroplane Co.

PYROMETERS
Foxboro Co., The, Inc.
Shore Instrument & Mfg. Co.
Taylor Instrument Companies

RADIATORS
Ajax Auto & Aero Sheet Metal Co.
A-Z Co.
Bush Mfg. Co.
El Arco Radiators Co.
Livingston Radiator Co.
Rome-Turney Radiator & Mfg. Co.

SCELEROSCOPE
Shore Instrument & Mfg. Co.

SEA SLEDS
Murray & Tregurtha

SHOCK ABSORBERS
Wood, J. W. Elastic Web Co.

SPARK PLUGS
Champion Ignition Co.
Johns-Manville Co., H. W.
Pyro Ignition Co.
Rajah Auto Supply Co.
Splitdorf Electrical Co.

SPEED INDICATORS
Foxboro Co., The, Inc.
Johns-Manville Co., H. W.
Stewart Warner Speedometer Corp.

STABILIZERS
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Martin Arodynamic Stabilizer.
Sperry Gyroscope Co.

STARTERS
Bijur Motor Lighting Co.
Christensen, The, Engineering Co.
Dayton Engineering Laboratories Co.
Motor Compressor Co.
Northeast Electric Co.
Wagner-Hoyt Electric Co.

TACHOMETERS
Johns-Manville Co., H. W.
Nelson Blower & Furnace Co.
Queen-Gray Co.
Stewart Warner Speedometer Corp.
Veeder Mfg. Co.

TANKS
Janney, Steinmetz & Co.

TELEPHONES
General Accoustic Co. (Aviaphone).
Streator Electric Co.
Telautograph Corp.
Western Electric Co.

THERMOMETERS
Foxboro Co., The, Inc.
Taylor Instrument Companies

TIRES AND RUBBER
Goodyear Tire & Rubber Co.
Hodgman Rubber Co.
United States Rubber Co.

TOOLS
Browne & Sharpe
Cooper, The John D., Aeroplane Co.
Hall-Scott Motor Car Co.

TRUCKS AND TRAILERS
Federal Motor Truck Co.
Four Wheel Drive Auto Co.
Nash Motors Co.
Packard Motor Car Co.
Sechler & Co., The
Service Motor Truck Co.
White Co.

TUBING
Empire Art Metal Co.
Frasse, Peter A., & Co.

TURNBUCKLES
Aero Mfg. & Accessories Co.
Ajax Iron Works
C. E. Aeroplane Works
Dillner-Meyer Mfg. Co.
Erie Specialty Co.
National Aeroplane Co.
New York & Hagerstown Metal Stamping Co.
Standard Screw Co.

WHEELS
Ackerman Wheel Co.

WIRE
American Steel and Wire Co.
Electric Cable Co.
Roebling's, John A., Sons
Simplex Wire and Cable Co.

WIRELESS
American Radio & Research Corp.
American Wireless Tel. Co.
Cutting & Washington.

WOODS
Alcock Co., John L.
American Balsa Corp.
Chetham Lumber Co.
Delatour, J.
Dutton, A. C. Lbr. Corp.
Ludlow, Israel
Mengel, C. C., & Bros. Co.

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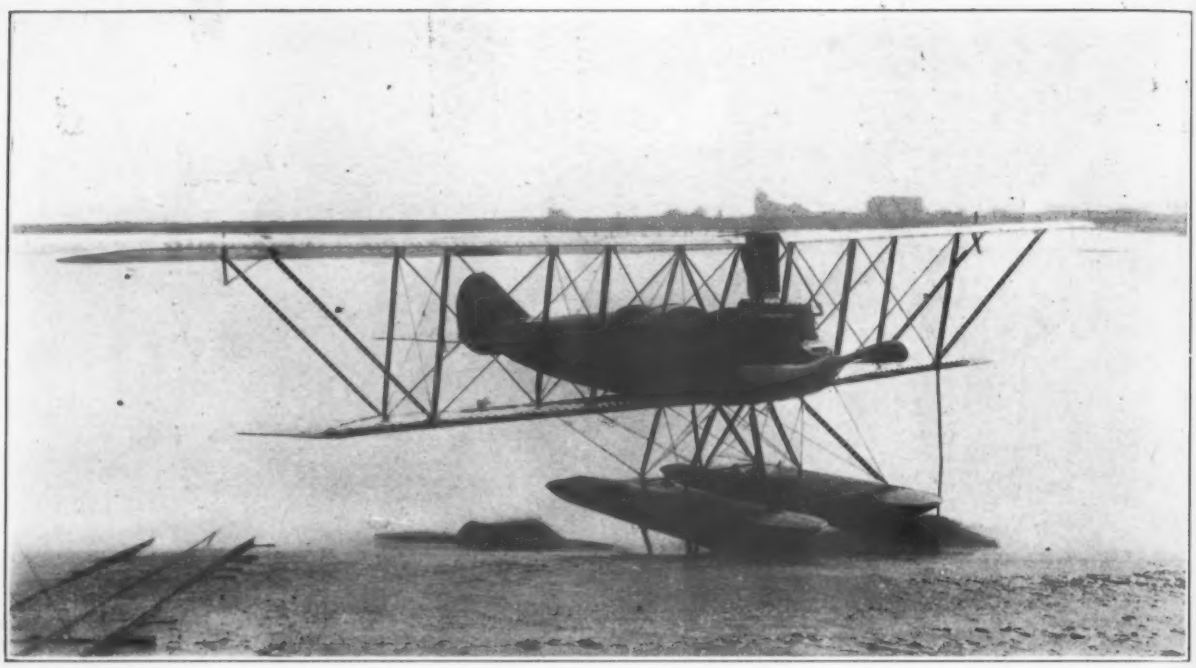

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